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The Implementation of Total Productive Maintenance in The Libyan Heavy Industry

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The Implementation of Total Productive Maintenance in The Libyan Heavy Industry

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Declaration of Authorship

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- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
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"O my Lord! Increase me in my knowledge!"

Quran 20:114

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Abstract

Faculty of Engineering and Computing

Doctor of Philosophy

The Implementation of Total Productive Maintenance in The Libyan Heavy Industry

by Mohamed ALOROM

Total Productive Maintenance (TPM), recently interests many major industrial companies, for the need to maintain the physical assets and the continuity of work. According to the Japan Institute of Plant Maintenance (JIMP), the (TPM) is based on eight principles: focused improvement, autonomous maintenance, planned maintenance, training and skills development, initial phase management, quality maintenance, TPM in Office, and safety environment. Through the implementation of those principles, an increased productivity can be achieved by reducing faults, improving quality, delivering times when specified, improving working conditions and raising the morale of the workers. This Research focused on factors and obstacles that effect this program.

The research aims to design a framework that identifies the most important factors that affect the success of the application of TPM, as well as the tools and techniques that help in the application process. To determine the factors and obstacles when applying TPM, Libyan Iron and Steel Company LISCO has been selected as case study.

This study analyzed impediments and obstacles to the implementation procedure and revealed key success ranked factors concluding with a conceptual framework for a successful TPM implementation along with the identification of tools and techniques to support implementing TPM. Also, TPM cannot be applied unless there is cooperation and coordination between the maintenance department and other sections of the company. Accordingly, this research also provided several recommendations, including the application of the concepts and principles of TPM in the company and make it the responsibility of everyone, and work in light of the proposed improvement plan.

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Chapter 1

Introduction

This chapter addresses a general introduction and background to the current study as a competitive strategy. It also, gives a general idea about the situation of the Libyan economy and research and development. Further, some facts about the Libyan Iron and Steel Company (LISCO), as a case study are included in this chapter. This chapter also, demonstrates the problem statement and the research outlines. The expected contribution to knowledge will be listed. Finally, briefing of the research methodology, research design and overview of the thesis will be given.

1.1 Background

Today, organizations, both services and manufacturing, are experiencing competitive business environments, and thus, achieving and sustaining competitive advantages in global marketplace which determines success for both public sector and private sector individually and the economy as a whole. This could be gained by focusing on improving the processes and the operation, reducing the cost of both the process and the product and increasing the volume of production while maintaining a satisfying level of quality and acceptable prices. As a survival step, numerous companies are attracted to the manufacturing techniques to track the rapid rhythm of the competitors, and to gain a competitive advantage and to reach the world class manufacturing level. Ahuja and Khamba (2008a) pointed out that, these requirements forced the manufacturing organizations to Adopt a highly reliable, available and maintainable manufacturing systems by applying proactive market driven strategies to stay competitive (Ahuja and Khamba, 2008a). According to Sahay et al (2000), cited in (Seth and Tripathi, 2006), responding to the modern manufacturing requirements, large number of organizations are attempting to achieve world class performance by various business solutions, but the total quality management (TQM) and TPM are the most widely accepted techniques. However, not all companies implementing these techniques were successful in the past, because the facilities were not as effective as they are today. Nowadays, developments in telecommunications, internet, and diffusion of the IT make the cooperation between companies easier; furthermore, the causes of failure of a company can be avoided in other companies. Also the communication process and the documentation in the organizations, which are required to implement manufacturing techniques successfully, now are available. In addition, the development of information technology made the organizations update the use of advanced technologies on the provision of high-quality and timely information, as well as to facilitate a high degree of communication and integration among the entire business units (Salaheldin and Eid, 2007).

The organizations that are willing to success and to achieve world class manufacturing level must give up using the reactive maintenance and start using proactive maintenance, which is more effective and efficient (Ahuja and Khamba, 2009). Willmott (1994a) referred that "Just-In-Time will not work unless you have highly reliable and effective equipment, where the interface between people and machine is maximized - which is a major objective of TPM". According to Jackson (1999) cited in Pomorski (2004), the Integration between TPM and other continuous programs such as TQM and JIT to achieve the greatest improvements in quality, reliability, cost, and time (Pomorski, 2004). TPM is one of these techniques, which holds the potential for improving the equipment productivity and quality. Importing some manufacturing techniques and philosophies such as TPM could help the organization to maintain the existing equipment instead of replacing new ones, where such techniques may make the machines at great condition of performance for a longer time, T. Bartz and Barth (2014) believed that, improving industrial performance and competitiveness were definitely gained by TPM. Nakajima (1988) said that TPM is a proactive maintenance that optimizes equipment effectiveness and gets rid of losses involving all employees through small group activities. TPM has a positive impact on several indicators of performance. It can increase productivity by increasing the effectiveness and availability of the equipment, increase the quality and capability for delivery commitment. Similarly, implementation of TPM improves the productivity and employees working efficiency and also improves the effectiveness of the equipment and a positive tendency towards the company. Therefore, equipment maintenance is a necessary function in manufacturing companies. In this very competitive environment, organizations should consider maintenance function as a possible source for cost reduction and competitive utility (A. Jain and Singh, 2014). In addition, it leads to a reduction in accidents as a result of cleaning, organizing and maintaining the equipment, and raises the morale of workers. This strategy seeks the cooperation and interaction between the maintenance and the rest of manufacturing functions. Machines, raw materials and production method are vital elements to enrich the industrial progress as well as skilled labour. The quality of production is due to the quality of all the aforementioned production elements. However, equipment is not necessarily to be new in order to work effectively. New equipment cannot continue to function efficiently with high quality and effectiveness unless it finds the appropriate maintenance. The functions of maintenance systems in manufacturing is responsible for ensuring the continued production system capacity in high grade of productivity and quality (Rich, 2001). Leflar (2001) Mentioned that People widely believe that new equipment is "the best that it will ever be", and its condition will deteriorate with continues use in production, then it will need to be replaced.

The TPM concept brought a new idea about machines which is replacing an equipment with a new one is the worst case scenario. As long as we deal with a machine, the more we know about it the better is the case. Substitution of machines depends on their technology limitation, not because they have deteriorated and became ineffective in performance. Ljungberg (1998) has pointed out that, it is very obvious that the new production process and the technology associated with it, is adversely affecting the overall equipment effectiveness due to the inexperience of operators and maintenance crews, contrary to the old processes that they were familiar with.

TABLE 1.1: Innovation rank. The global competitiveness report 2008-2009 (Sala-I-Martin et al., 2008).

1.2 The need of research

The industry sector is of great importance to the advancement of the country's economy, and for developing this sector, it is important to keep pace with the times by using modern technology and advanced management techniques in order to increase production rates and quality. All of this will not be achieved unless the studies and researches are made available to show the possibility of application and the utilization of these techniques, and to determine the factors leading to success and the obstacles leading to failure and benefiting from the experiences of others. Libya surpasses in macroeconomic indicators, with one of the highest budgetary surpluses and one of the lowest government debts worldwide. This strength point should be used to enhance the innovation and sophistication which are below levels found in countries in a similar stage of development. The lack of attention to training and development in the human resources, the lack of cooperation between educational institutions and industrial organizations in the research and development and the non-use of advanced management techniques, made the industrial sector suffers from problems that led to the slow growth significantly, even though the expenses on this sector gone beyond the reasonable. Alqadhafi (2000) cited that despite significant investments in the industrial sector, which exceeded four billion, but the contribution of this sector in the structure of GDP did not exceed 3.5%. According to the Global Competitiveness Report (GCR) published in 2008, the Libyan innovation initiatives and training are very weak. Table 1.1 shows Libya's rank out of 134 country, (Sala-I-Martin et al., 2008). The research in Libya and Arab region in general does not have a good site on the priorities of development plans and what was accomplished is just in piecemeal efforts and was not often collected in a comprehensive orientation at the national or regional level. Alqadhafi (2000) has referred that, the decline in the quality of products in Libya is due to the absence of research and development units and quality control.

The lack of development and searching for the root of problems lead to defects in the production, and deterioration in the productive capacities, which ended in shutting down the plants. Most factories in Libya operate at less than half the maximum design production capacity. Further, in many cases work only at 25% of its design production capacity (Alqadhafi, 2000). He, also, referred that the annual report submitted to the Basic Peoples' Congress in its second session in 1989, showed the industrial sector in which the investment allocated for it exceeded the amount of LD 4315 million ($1=LD 0.3 at that time), including more than 250 factories and employed more than 47,000 workers/producers. It was noted that only 17 local products achieving production exceeding 60 percent of the maximum capacity of the producing factories thereto, the production rates in other factories ranged between 9% - 59%. He also added that there

were some practices contribute negatively toward increasing the overall costs and decreasing the production rate as result of the deterioration in organizing the productive process, for example, the lowering effectiveness of the present methods to provide raw materials and spare parts, lowering standards and methods of maintenance services, dearth of attempts to manufacture spare parts locally, dearth of attempts at planed schedules and effective organization for workers at the factories (Alqadhafi, 2000).

According to General Planning Council report issued in 2003, productivity of manufacturing organizations in the industry sector is very low, which is reflecting small contribution in GDP, in spite of billions of dollars invested in this sector during the last two decades (CGP, 2003). The share of manufacturing in GDP increased from 5% in 1970's to around 15% in 2005 of the total GDP in Libya (Yousef, 2007). The industrial sector which totally owned by the state, is experiencing a productive deficiency, even though the government spending on this sector exceeded 4.5 billion dollars in the last two decades. These challenges are forcing the manufacturing organizations globally to foster high reliability, availability and maintainability in the manufacturing systems by implementation of various strategic and proactive market driven strategies to remain competitive in a highly dynamic environment (Antipolis, 2002). If some of the western industrial organizations with cultures different from Japanese culture were rushed to embrace the Japanese philosophy and have successfully implemented this method through amendments to the methods of management based on the theories of traditional management and transition to lean techniques and achieved global competitiveness indices, the existing institutions in developing countries are most in need than others to accelerate implementation of TPM strategy, because they are just technology consumers, thus, they need to achieve maximum benefit from this technology and prolong its service life, which are attainable only through the pursuit of more effective management methods like TPM, TQM and other philosophies.

The focused efforts in Libya were on the transfer of technology and expansion without building a real local capacity in the development of products and production methods and paying more attention to the development of training needs. However, industrial enterprises cannot survive for long if their products have not competitive advantage in the function and the cost, which without them the project will be unable to meet the changing needs of the marketplace. It will be doomed to extinction for each project fails to achieve this aspect of competitiveness based primarily on research and development outputs. Figure 1.2 shows the defective and rejected production in one of the rolling plants in LISCO which reached 34.02% in 2007 due to poor conditions of equipment and process (Production, 2008), in addition, the quality of maintenance plays the main role here. Maintenance quality has a significant impact on profitability (Eti, Ogaji, and Probert, 2004).

Libya is seeking to develop its production ability with high quality to meet the customer expectations by the highest technology available (Hirano, Khan, and Hussain, 2008). It is very easy to get the newest technology available, but how to keep it running at its perfect level is the key question. Many companies found that TPM could deal with most of their production and maintenance problems. It was considered as a gateway to the development of the assets, the process, and the manpower. Sia and Shamsuddin (2007) mentioned that most research studies indicated that a well-managed TPM implementation not only enhances the machines' reliability and availability but also improves production output, quality and creates a culture of team-work spirit to own

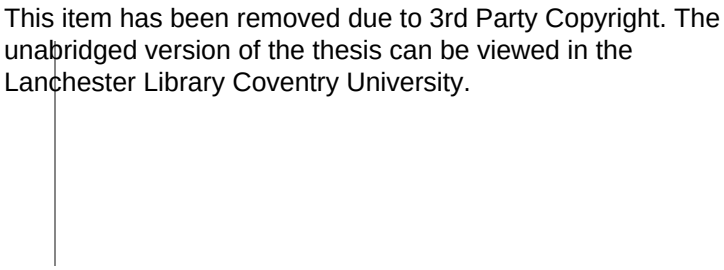

FIGURE 1.1: The rejected and defective products in one of LISCO plants (LISCO, 2010).

the equipment, while increasing individual work skills (Sia and Shamsuddin, 2007).

1.3 Problem Statement

Introducing such strategy like TPM is not an easy task especially that Libya is one of the developing countries, which suffer from lack of experience. Lack of experience of applying change management philosophies made the task of installing TPM a major challenge. The target of the application of TPM is the desire for access to the multiple benefits that TPM aims to. The process of application can be made according to well-known steps that were recommended by experts in this area, which are represented in the 12-step. Though, there are variables represented in the obstacles, barriers and factors affecting remarkably the process of application. Implementing TPM was considered heavily burdened by various obstacles (Cooke, 2000). Unsuccessful implementation of TPM program has been attributed to various barriers (Ahuja and Khamba, 2008b). On the other hand, there are factors and sub-factors that affect the success of implementing TPM. These factors are based on the barriers and obstacles to the implementation of TPM.

1.4 Research Questions

The overall purpose of this study is to generate new knowledge and understanding, and hence, establishing upon the existing TPM system theories that are based on the results of previous research, the main purpose is to provide a broader and deeper understanding of the barriers that affect the implementation of the TPM in the environment of the case study organizations.

The main research question to be asked in this study is:

What framework can be developed to enable TPM to be successfully implemented within a Libyan heavy industry organisation?

1.5 Research outlines

1.5.1 Aim of the research

To investigate the factors affecting successful implementation of Total Productive Maintenance in Libyan Manufacturing Organisation Environment.

1.5.2 Objectives

- To identify the general factors affecting the success of implementing TPM.
- To assess the existing TPM activities within LISCO plants.
- To examine the extent to which the Libyan manufacturing environment suited to the implementation of TPM pillars.
- To develop and document a generic framework to assist in the development of a TPM implementation methodology in LISCO.

1.6 Cooperation with the company and TPM team work

A Libyan case study was carried out at the compound LISCO after a request has been made by Coventry University through Libyan embassy in London, requesting management of LISCO to allow the researcher to carry out the research according to the application of research ethics.

The study was carried out at LISCO plants, which are currently implementing TPM. They provided the researcher with a letter dated on 08 of September 2009, which gives permission to start the research in LISCO. The company directors, and the Supervisory Committees of TPM implementation expressed their readiness to help the researcher and cooperation to follow-up the implementation steps and obtain the preliminary results. This assistance can be summarized in the following points:

- Access to the reports of the supervisory, executive committees, and Counsels;
- Access to the organizational structures of the TPM committees;
- Model equipment and method of selection;
- Learn about the projects that involved the continuous improvement and their target;
- Visit work sites and conduct interviews;
- Meeting with the TPM committee in LISCO;

1.7 Expected contribution to knowledge

1. The research contributes to the body of TPM knowledge and practices in a number of ways;

2. The research and investigation in this subject has a very little attention in Libya and it will certainly contribute to the development of TPM in the field of manufacturing industry;

3. The research will contribute to the development of TPM in multi plants and heavy industry;

4. The lack of empirical studies published on TPM in the Libyan manufacturing industry, gives this research an important and vital factors;

5. The chosen case study will contribute to the Libyan economy due to the important role of the Libyan Iron and Steel company in the Libyan economy.

1.8 Research methodology

In order to achieve the objectives of the research correctly, both primary and secondary data have been used. Prior to collecting primary data, it is wise to explore the secondary data through surveying the literature and published reports. Churchill (1999) pointed that "Do not bypass secondary data, begin with secondary data, and only when the secondary data are exhausted or show diminishing returns, proceed to primary data".

This research seeks the implementation of TPM and its common factors that affect positively or negatively to its success, by means of literature. Through an extensive literature review, researcher seeks for the articles that provide a reply to the question: What are the key factors for TPM implementation success? These factors are inclusive of all the sub-factors mentioned in the review. The online database search saves time and effort and it is an effective and efficient means to search for information in ways that may be not easy or impossible to duplicate with printed resources. Moreover, it is a convenient way to produce a bibliography customized to the needs of individual research (Taylor, 2000).

The key method used to investigate for these factors was to ask the interviewee which characteristics of the organization influenced successful implementation. That will be done by questionnaires, interviews and documents. The sources of literature were carefully chosen to study some cases that implement TPM, considering the level of technology, experience and type of industry. On the other hand, the case study was chosen to assert and classify the results that were obtained from the comparative literature. The study of literature related to the implementation of TPM and the study of industrial environment in Libya will lead to build a framework to be taken as a guide to help this environment installing TPM in a successful manner. The literature review investigates a list of papers, books and thesis which address TPM implementation. It can be noticed that Figure 1.2 provides a clear and complete description of the specific steps to be followed in this research. These steps will be described in sufficient details throughout this thesis.

First, the material contained in the Review of the Literature is extensively discussed. The factors affecting the TPM implantation in general will be considered next. Then, the design provides a theoretical framework within which to incorporate the materials discussed in the previous steps. The criteria for choosing appropriate company to

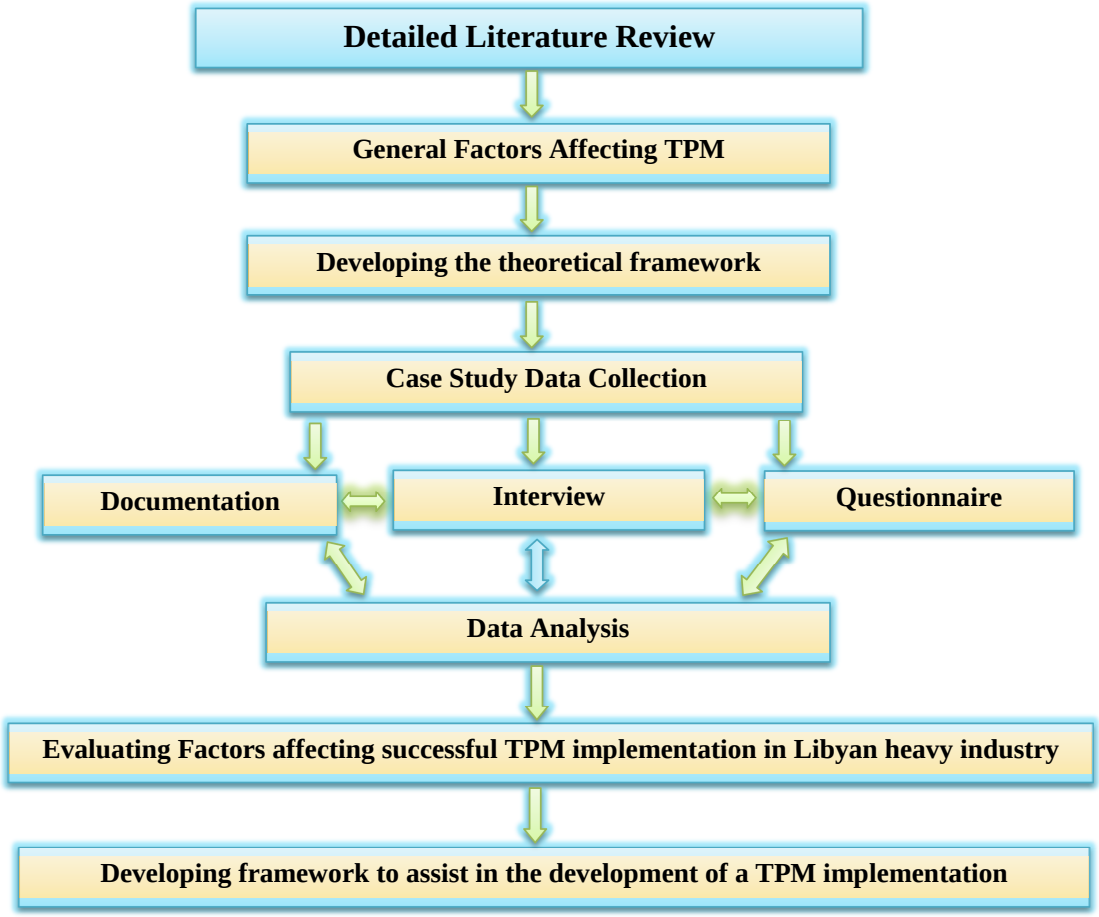

FIGURE 1.2: The research design flowchart.

study, including issues of size, age, and tenure of employees, opportunities for observation and access to company documentation and employees is taken into account next when data is collected from the units of the company that the author received entry into them and met his criteria and gave him unlimited access to the organization. Further, employees of the two chosen units were given the opportunity to participate in confidential interviews and ended up interviewing the majority of the employees of these units as well as the middle tier and top management of these two units. The author also relied on the analysis of the organizational documents and questionnaires. The interviews, documents, and questionnaires were described in the Data Analysis Chapter, and the interview protocols as well as questionnaires were placed in appendices to the dissertation.
Furthermore, the results of the data analysis are presented. The data were collected and then processed in response to the problems posed in Section 1.4 of this dissertation. After analysing the data collected from the interviews, documentations, and questionnaires, the findings will contribute to the assessment and evaluation of the TPM factors in the Libyan heavy industry. Finally, a theoretical framework is developed to accommodate the development of TPM implementation of TPM in Libya.

Next, an overview of the thesis is discussed.

1.9 Overview of the thesis

This thesis consists of seven chapters, which are briefly outlined below.

Chapter one: Introduction: covers the areas of research background, research problem, questions and aim and objectives. the chapter also provides the contribution of the research, overview on the research methodology and layout of thesis.

Chapter two: Methodology: defines the research in the context of a social science problem, justifies the research approach and explains the methods and research processes used in details with a brief outline of the research process. The goal of this stage is to complement and validate the data collected from the case study stage.

Chapter three: Literature review: presents and discusses what has been written in relation to the subject's areas of Interest. It provides a general overview of the TPM philosophy, and a summary of published literature on the problems encountered when organizing the work to adopt such a philosophy. Continuous process industry and lean and features of process industries were discussed. A review of current literature on maintenance practice and TPM with particular reference to steel industry is also presented and the chapter concludes with a personal contribution to the established TPM paradigm by developing a conceptual framework.

Chapter four: Case Study background: reviews the philosophies that have influenced Libya's social and economic development during the twentieth century as well as the steel industry and market. Then, there is description in detail about Libyan Iron and Steel Company (LISCO) and an overview of the Steel-making process at LISCO was detailed. TPM journey in LISCO was discussed.

Chapter five: Data analysis: it is concerned with analysis of the case study collected data. This chapter identifies the major issues related to the activities and factors affecting TPM system through the investigated organization. This chapter, also, provides further discussion of the main findings of the research on the basis of theoretical perspectives. A further aim of this chapter is to explain the implications of these findings, the critique of methodology adopted, and the findings.

Chapter six: Discussion: this chapter provides further discussion of the main findings of the research on the basis of theoretical perspectives. A further aim of this chapter is to explain the implications of these findings, the critique of methodology adopted, and the findings.

Chapter seven: Conclusion : provides a conclusion of the study in the light of the specific research aims and objectives. This chapter includes, meeting the aims and objectives of research, contribution to the knowledge, the recommendations for further researches and the limitations of research.

Chapter 2

Research Methodology

2.1 Introduction

Research methodology is one of the most significant parts of the research. This is a framework or blueprint of the methods and techniques that would be adopted by the researcher for answering the research questions, a plan that helps by providing a dimension to the researcher. This chapter contains the methodology that is adopted by the researcher along with the justification for the selection of the particular methodology. The methods and tools have been briefed along with the issues related to them to counter the hurdles that the researchers might be faced while adopting those procedures. The research contains both primary and secondary data, and both qualitative and quantitative data have been collected.

2.2 Background

The methodology is an organized steps followed by the researcher to increase the knowledge, such as the identification of research questions to answer, defining the concepts, identifying the variables and developing hypotheses around them. This is followed by determining the samples and collecting the data and then performing the analysis and accessing the results. Floyd (2010) defined the scientific methodology as a system of explicit rules and procedures upon which research is based and against which claims for knowledge are evaluated (Floyd, 2010).

The methodology is also the way in which a specific task is carried out and the general principles guiding an investigation. The diversification of the methods to collect data would reduce the component of bias and integrate data with each other to fulfil the required job. Moreover, choice has to be made between, for instance, quantitative or qualitative approaches or/and between experimental, surveys based or positivism approaches and so on.

The selection of the proper method of research is very important because it has an influence on the quality and the validity of the obtained results, hence, adopting an inappropriate technique may give incorrect results. This research, however, is based on mixture of qualitative and quantitative methods. Bryman (1996) pointed out that the terms qualitative and quantitative research came to denote much more than the ways of gathering data, it came to signify divergent assumptions about the nature and purposes of research in the social sciences. In some research, because of considerations relating to them and their circumstances, a combination of methods can be used to obtain the advantage of both. Though, this combination does not make a third way, because it does not blend results in a method different from the qualitative and the quantitative

method. The combination of quantitative and qualitative research methods in many cases provides broadly consistent data Bryman (1996). Combining quantitative and qualitative would seem to allow the various strengths to be capitalized upon and the weaknesses offset Bryman (2001).

2.3 Definitions of research

The research is an indispensable human activity for the people to develop science and progress to Nations. The various types of researches are important including all specialties whether it is human, natural, theoretical or applied. The old nation looked at the problems and sought to remedy them, and worked on the development of life and avoid the risks. People now continued the development approach using research, even managed to invade the space, and were able to make the latest technology in the field of computer and transport and communications and otherwise.

All this could not have been achieved without resorting to a research. The activity of research is based on the verification of precise observation and data collection and analysis in an appropriate manner. Moreover, it depends on comparisons, balances, the study of cause-and-effect and identify the methods of treatment. In addition to surpassing the stage of trial and error that cost society a lot of effort and time and available resources which are scarce compared to the reoccurring needs of humans. Generally, searching in a branch of science leads to make it easier to search in another branch as there is a correlation between different branches of science. Research is all about finding out something which you do not already know. Dane (2010) defined research as a critical process for asking and attempting to answer questions about the world. Research in common parlance refers to a search for knowledge. One can also define research as a scientific and systematic search for pertinent information on a specific topic. In fact, research is an art of scientific investigation (Kothari, 2004).

In this study, the researcher focused mainly and utilized a mixture of quantitative and quantitative method of research. Furthermore, this research is considered an explanatory research due to the reasons listed hereinbelow.

2.3.1 Exploratory, descriptive, analytical or predictive research

Exploratory research can be used when the researcher has very few or no previous studies and then there is limitation of information that can be referred to. This type of research is done because the problem has not yet been clearly defined. The aim is to look for hypotheses, patterns or ideas that can be tested and will form the basis for further research. The most used techniques in exploratory research would include case studies, observation and reviews of previous related studies and data.

Descriptive research can be undertaken to identify and classify the elements or characteristics belonging to a specific issue or problem. It is also widely known as statistical research. The Statistical techniques are frequently used to collect data, which are often quantitative. It is a very essential part of a proposal involving descriptive research. Descriptive researches test problems in more depth than exploratory research.

Analytical research is a type of descriptive approach to suggest or explain why or how something is happening. An important feature of this type of research is aiming to

TABLE 2.1: Some differences between Quantitative and Qualitative research (Bryman, 1996).

identify and measure relations between the studied phenomena.
Predictive research is aiming to forecast intelligently on future possibilities. These research works has been carried out based on close analysis of available evidence of cause and effect. Statistical techniques are often used to collect and analyse the required data.

2.3.2 Quantitative and qualitative research

Quantitative Method: research based on objective, numerical measurement of facts; statistical and often experimental; again often associated with the positivist approach. (Bryman, 1996) Said that "Quantitative research is associated with a number of different approaches to data collection". The social survey is one of the main methods of data collection. Quantitative implies an emphasis on measurement and analysis of relationships between variables not processes (Denzin and Lincoln, 2000). The quantitative data can help to test statistical relationships between the problems and the causes; provide accurate quantitative data to prove the existence of certain problems, but it does not measure the required, and cannot explain the underlying causes of situations.

Qualitative Method: research based on non-numerical or even none measurable evidence; based on the researcher's judgment of situations; descriptive approach. (Bryman, 1996) Cited that "Qualitative research have been employed by social scientists for many years. Participant observation is one of the main methods". It is also, the focus in dealing with the current events experiencing from both past and present, based on what the researcher understood from them, and implies relations that can be observed. (Denzin and Lincoln, 2000) Pointed out that qualitative research is a situated activity that locates the observer in the world, it contains of a set of interpretive, material practices that make the world visible, and it emphasizes the quality of entities and processes. (Stake, 1995) Has pointed out that "in quantitative and qualitative there are three major differences: the distinction between a personal and impersonal role for the research; the distinction between explanation and understanding as the purpose of inquiry; the distinction between knowledge discovered and knowledge constructed". The qualitative data subject to biases of interviewers, observers and information providers. It is not representative in general and provides a comprehensive understanding of the context of program / project in order to interpret quantitative data. Table 2.1 shows some differences between qualitative and quantitative research (Bryman, 1996).

2.4 Research Methods versus Research Methodology

This section is allocated to shed light on the differences between research methods and research methodology. As regards research methods, they tend to stand for the processes or techniques that a researcher uses to carry out their empirical studies such as focused interviews, participant observations or questionnaire surveys (Dawson, 2002). That is, all the tools or methods that a researcher relies on to collect data of a research study and find a solution to a problem are termed as research methods. More specifically, (Kothari, 2004) identifies three groups of research methods, which are as follows:

1. The first group comprises the methods which pertain to the collection of data. In other words, the methods will be used here when the available data are not adequate to obtain the required solution;

2. The second group includes the statistical techniques which are undertaken to establish a relationship between the data and the unknowns;

3. The third group is related to the methods which are adopted to evaluate the accuracy of the findings attained.

Concerning research methodology, both Daniel and Sam (2010) postulate that methodology is the discipline, or body of knowledge, that contains the principles and standards necessary for choosing, structuring and using research methods. The methodology can be either qualitative or quantitative. (Daniel and Sam, 2010) went further and indicated that research methodology is wider than research methods on the grounds that the former entails theoretical principles as well as framework that provides guidelines about how research is done in the context of a particular paradigm. With this in mind, (Kothari, 2004) affirms the potential of having sufficient knowledge not only about the way of developing specific tests or applying specific research techniques, but also about which of these methods or techniques are relevant to the phenomenon under study and research questions and which are not, and what would they mean and indicate and why. Related to this, research methods constitute a part of research methodology simply because the latter includes a range of dimensions such as the logic behind the choice of specific methods in the context under study and their capability of helping a researcher gain valid results.

Addressing the point relating to the distinction between research methodology and research methods, (Sarantakos, 1998), for instance, points out that the methodological framework that a research embraces often determines the process, structure and content of research methods used to explore the phenomenon under investigation. For instance, observation as a method of data collection can be used both quantitatively and qualitatively. Nonetheless, participant observation is often adopted in qualitative studies, whereas non-participant tends to be employed more in quantitative research studies. Likewise, in interview method, structured interviews are likely to be utilised in quantitative research studies while unstructured interviews tend to appear principally in qualitative studies.

2.5 Justification of the research approach adopted

This section is allocated to discuss the reasons for adopting the mixed methodology framework in this research study. (Jankowicz, 2000), for instance, contends that the

decision of choosing a specific methodological approach in a specific study pertains to both the research objectives and the questions that the researcher intends to explore. Put it another way, a qualitative approach tends to be more appropriate if the research objectives require a deeper understanding of the phenomenon under investigation. As Ghauri, Gronhauge, and Kristianslund (1995) aptly put it, 'Qualitative methods are more suitable when the objectives of the study demand in-depth insight into a phenomenon' (Ghauri, Gronhauge, and Kristianslund, 1995).

This study has adopted the mixed methodology, i.e. both quantitative and qualitative approaches. The use of both quantitative and qualitative methods in the same study is known as triangulation. (Denzin, 1978), for instance, have stressed the potential of applying methodological triangulation in research empirical studies and argues that the goal of this triangulation is playing each method off against the other so as to maximize the validity of field efforts. Nevertheless, the main difficulty of undertaking the methodological triangulation in any research study is relevant to the time limit and the availability of some important resources such as the funding. It should be emphasised that this research study used the qualitative semi-structured interviews as the main method, which will be further explained in the coming section. Many researchers e.g. ((D. Amaratunga and Newton, 2002), (Gummesson, 1999)) have addressed the importance of using qualitative methods in research studies through outlined some of its advantages, among these: they provide a deeper understanding of the social world, they are often based on a small scale sample and they allow new issues and concepts to be explored. More precisely, D. Amaratunga and Newton (2002) states that qualitative methods are valuable when a researcher intends to unearth a new area, and to supplement, validate, or reinterpret quantitative data gathered from the same setting. (Bell, 1999) indicates that qualitative research methods are often used to understand participants' perceptions of the world. They search for insight rather than statistical analysis.

2.6 Research techniques adopted and generating the questions

The literature reviews have been used to highlight the factors, barriers and difficulties that affect the implementation of TPM within an organisation. Based on previous studies, the researcher has developed the set of questions that have been used in both questionnaires, and interviews. According to M. Easterby-Smith and Lowe (2002), reviewing the literature is a research activity all in itself. It is not unusual to see articles that publish reviews of the literature in a particular field. These invariably focus on research questions which have been raised and highlight the main influential conceptual or empirical studies conducted in the area. This research study has adopted the semi-structured interviews (qualitative research) as the main method, whereas questionnaires were employed quantitatively as a second method in order to provide triangulation and reducing the bias and limitations of any individual method. In this sense, triangulation can give the researcher a chance to take advantage of the benefits of the different types of approaches and it can also play a pivotal role in gaining more accurate answers to the research questions under investigation. Addressing the advantages of undertaking methodological triangulation (i.e., using more than one method for collecting data) by researchers, both Hussey, Hussey, and Hussain (1997) suggested that it is perfectly possible, and even advantageous, to use both qualitative and quantitative methods for collecting data. A questionnaire survey providing quantitative data could

be accompanied by in-depth interviews to provide qualitative insights and illuminations'. (Hussey, Hussey, and Hussain, 1997).

Based on that, the researcher has employed methodological triangulation in this phenomenological study through employing different research methods. To put it more accurately, the researcher has used the following methods for collecting the data of the current research study: archival records, documents (TI), semi-structured interviews (T2) and questionnaires survey (T3). Open-ended questioning was given to the interviewees to fill it in at different levels of managers and supervisors at maintenance, production department in addition to the top managers and TPM seniors of case study organisations. It is worth mentioning that some other researchers (e.g. (Fielding and Fielding, 1986), (Flick, 1998)) have rejected the assumption that convergence of results from different research approaches can be interpreted as a sign of validity, arguing that the inaccuracy of one method complement the inaccuracies of another.

As already mentioned, a qualitative data has employed through using semi-structured interviews as the main research method. This kind of interviews is likely to be carried out in a way that is neither an open every day conversation nor a closed one (Kvale, 2007). Saunders, Lewis, and Thornhill (2007), in turn, affirm that semi-structured interviews are often deployed in qualitative research in order to understand mainly the 'what' and the 'how' research questions. The purpose behind a qualitative interview, as Richards (2003) argues, is a deep understanding rather than a sheer accumulation of data. Undertaking the qualitative semi-structured interviews in this study helped the interviewees express their own understandings in their own terms rather than 'fit their knowledge, experiences and feelings into the evaluator's categories' Patton (1990).

A multiple choice-closed question set questionnaire was also distributed on the entire workforce in the maintenance departments of case study organisations. The aim behind using this kind of the questionnaire is to supplement the qualitative data gained from the semi-structured interviews. It is worth noting that a range of documents such as minutes of meetings, reports and some other related papers and archives were also deployed to verify the results gained from semi-structured interviews and questionnaire survey. The questions of interviews were mainly based on the literature review information and the objectives of this research.

2.7 Case Study

A case study could include a single case like a person, a school, etc, or multiple cases like several schools or people ((Gillham, 2000), (Yin, 2003)). According to Yin (2003), the case study research is often of qualitative nature and is favourable if 'how' and 'why' questions are being asked. Given that 'meaning' is seemingly the main concern of the qualitative approach ((Bogdan and Biklen, 2007), the individuals' viewpoints and perceptions about a specific phenomenon are often the focus in the case study research. Both Ritchie and Lewis (2003) view the main defining features of a case study as being 'multiplicity of perspectives which are rooted in a specific context'. From a naturalistic approach to inquiry, Nunan and Bailey (2009), in turn, elicited two essential commonalities among various definitions of case study presented by different researchers: the first and foremost is the notion that the case is a bounded instance'

i.e., it is defined within some kind of boundaries such as time (for instance, a pedagogical activity that has a time limitation such as a lesson) or role or place boundaries (teachers, or schools); the second important common factor is that 'the phenomenon is studied in context. The valuable characteristics of case study contain particularity, rich contextualisation, deep description, along with triangulations (Yin (2003), Nunan and Bailey (2009), Punch (2009)). Yin (2003) differentiates three main kinds of case studies: exploratory, explanatory, and descriptive case studies. Exploratory case studies are often conducted to define research questions and hypotheses or to verify the feasibility of the desired research procedures. Explanatory case studies, in turn, search for linking an event with its effects and are suitable for investigating causality. Descriptive case studies are often used to present a complete description of phenomenon within its context.

Zainal (2007) argues that case study research is, like any other methodological framework, has been subject to some criticisms. These criticisms have been principally based on the grounds of non-representativeness and the problem of not being able to provide generalisability in a statistical sense (ibid). In response to these criticisms, however, both Denzin and Lincoln (2000) point out that case studies can be generalised, on the premise that 'looking at multiple actors in multiple settings enhances generalisability'. Like (Denzin and Lincoln, 2000), Denzin and Lincoln (2000) holds the view that while survey research tries to generalise findings based on a sample that generalises to a larger universe, case studies are mainly used for analytical generalisations, in the sense that the researcher's aim is to generalise a particular set of results to some broader theoretical propositions. Based on the criticisms raised by some researchers in relation to the availability of adopting case study research, it might be argued that no research methodology is perfect, and therefore, researchers have to use data gained from multiple methods.

2.8 Justification of selecting number and type of case studies

During the design stage of case study, the researcher identifies what can be used to select single or multiple cases to study in-depth study and which techniques and data collection approach. Using multiple cases, each case must be treated as one case. Then each case conclusions can be used as information that contribute to the whole study, but each case remains one case. Choosing single or multiple cases is a key element, but a case study can include more than one unit. Yin (2003) referred that there are four types of case study designs, Single-case (holistic), single-case (embedded), multiple-case (holistic), and multiple-case (embedded). Single case study is usually used when the studied case is representing cases which are considered typical or extreme case (unique). Single case provides the researcher with an important opportunity to observe and analyze certain phenomenon which were taken into account by few people in the past. Inevitably, the appearance is important to use a single-case strategy through an actual case definition (Yin, 1994). Multiple case studies are those that combine several cases. The rationale for the use of multiple cases is to focus on the need to ensure that the results obtained from the first case are verifiable in other cases, and thus the need to generalize on the basis of these results (Yin, 1994).

The researchers must determine whether to study cases that are unique in some way

or cases that are considered typical, and may also specify the cases to represent a variety of geographic areas, and a variety of size parameters, or other parameters. The selection of a single-case or multiple-case is to refer to the purpose of the study in order to pay attention on where to look for cases and evidence that would answer the research questions and satisfy the purpose of the study (Zainal, 2007). This research study is explanatory and exploratory in perspective; it is interested in knowing that "what", "how" and "why" issues related to the identifying factors and difficulties affecting TPM implementation in Libyan manufacturing environment. However, LISCO was chosen as a single case study for this research, it is a large-scale manufacturing organisation. Yin (1994) cited that case study approach is appropriate when studying managerial processes, when the boundaries of the phenomenon and its context are not clearly evident (Yin, 1994). This steel company is consisting of ten plants with about 7000 employees. Moreover, LISCO company is the only company in Libyan manufacturing area applying TPM in its plants. The researcher decided to chose two plants out of the ten plants of LISCO. This decision was based on the recommendations of TPM committee in LISCO Company due to the fact that these two plants are in the advanced stages of the implementation process compared with the other plants (see Figure 2.1).

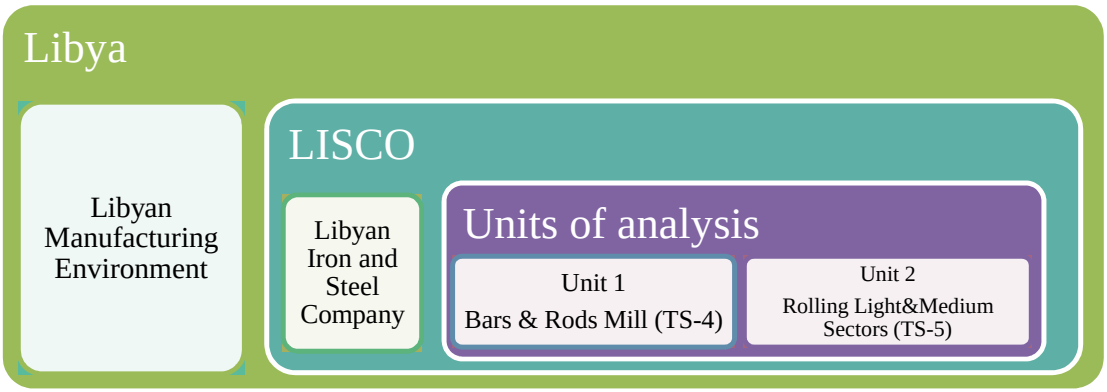

FIGURE 2.1: An embedded single-case design.

2.9 Data Collection

Methods can be used to collect data quantitative and qualitative methods as well as analytical approaches deductive and inductive. Quantitative approach is more accurate and rigorous because of use of mathematics, but it is difficult to place all human phenomena to count and Statistics. Hence, the need to resort to the qualitative approach is used, which requires careful observation and penetrating understanding of the reality of living. The research design is both qualitative and quantitative in nature and a structured questionnaire, applying the Likert scale, will be used to gather the data. The personal interview is the most common methods used in the case study, where it achieves principle of access to information directly from the person in question. The survey and case study are complementary and there is a relationship between them. Yin (2003) referred that the case study can be conducted alone or in combination with other methods, as all have complementary weakness and strengths. The data is classified to two types, primary and secondary. Secondary data sources include published,

unpublished, internal and external documents. the researcher starts gathering the information needed through the secondary data and any limitations in the data will be gained by the researcher efforts through the appropriate manner for the study. The case study approach uses several ways to collect data like interviews, questionnaires, and the observation which is necessary in most cases.

2.10 Document and archival sources

The term document in its precise meaning is a formal or semi-formal written legal documents and writings that address the issues of economy, such as orders, decisions, decrees, patents, conventions and political correspondence. The documents provide some valuable information that was obtained by others (Stake, 1995). Yin (1994) suggests that documentary information is sometimes essential for a case study topic. However, documentary information can take many forms and should be the object of explicit data collection plans. For example, letters, progress reports, minutes of meetings and administrative documents. He also added that the archival records can be service records, organisational records, charts and survey data. The documents provide some valuable information already obtained by others.

The analysis of company documents related to the subject of the study will provide us with information on the activities of the company, its goals, objectives, and mission. In addition, access to documents will give readings of financial, managerial and political statements. The most important use of documents is to emphasis and increase evidence from other sources (Yin, 1994). Document and archival records technique is based on the systematic and accurate description of the content of the texts written or audited by selecting the object and purpose of the study and defining the study population which its cases will be selected for the study and analysis of the content. After the researcher selects the documents to be studied, then the process of study and analysis will begin focusing on the information contained in the document. Clearly, the researcher must not try to infer from the document but only with explicit data mentioned therein. In this technique, the researcher follows the descriptive approach steps, where after defining the research problem and questions he will be directed to the completion of research and access to the results.

2.11 Interview

The interview is considered the main road to multiple realities (Stake, 1995). It is an oral questionnaire between the interviewer and the person or people to obtain information related to trends, opinions, feelings, motives or behaviour. Interviews are common in social life, and there are different forms of interviews. For example, job interview, media interview and police interview, and there are interviews for research study. The research interview is an important data collection approach in both quantitative and qualitative research (Bryman, 2001). Using interviews could help to gather reliable and valid data that is relevant to the research questions and help formulating such questions and objectives. Moreover, the interview can be structured and formal using specific and standardized questions.

It can be an informal interview, using an informal conversation, and it can be something else between these two (Saunders, Lewis, and Thornhill, 2003). Hancock and

Algozzine (2006) pointed that the interview is a very common form of data collection in case study researches. Interviews with individuals or groups allow the researcher to achieve rich and personal information. In order to ensure the success of the interviews, researcher should develop the interview guide, as the guide will identify appropriate questions that will be asked to each interviewee. These questions are designed to allow the researcher to obtain insight into the study's essential research questions, and thus the number of interview questions for a particular interview vary widely. The interview may be unstructured, semi-structured, or structured. Semi-structured interview is suitable for case study research. Using this approach, researchers ask specific questions in advance, but worded flexibly, and answers that provide preliminary answers to the questions researchers (Hancock and Algozzine, 2006).

The personal interview method is a face-to-face contact between the interviewer who will ask the questions and interviewee who will answer the questions (Kothari, 2004). Hussey, Hussey, and Hussain (1997), said that the interviews are a collecting data method in which selected participants are asked some questions in order to find out what they do, think or feel. The interview could be done individually between researcher and respondent so that the interviewees may feel free to express their opinion. The individual interview is the most commonly used interviews in social research and humanity. Also, the interview can be accomplished between an interviewer and group of interviewees, and what distinguishes the latter is it gives an in-depth data and can help respondents to remember the elements of information. Though, the group interview also has disadvantage which is that one of the interviewees may dominate the atmosphere of the interview or not given an adequate opportunity for others to express their views and some interviewee may be reluctant to mention their personal problems in front of members of the group.

2.11.1 Types of interviews

Herbst and Coldwell (2004) and Dawson (2002) have mentioned that, the interview typically happens whenever a researcher and respondent meet face-to-face or communicate via some technology like computer or telephone. They also added that there are three subtypes of interviews: structured interview, semi-structured interview and unstructured interview (Herbst and Coldwell, 2004).

Structured interview: Also known as standardized interview, it is commonly used in large scale survey researches. In this type of interviews, the researcher prepares a list of questions before the interview, and asks the same questions in every interview and often by the same sequence in order to ensure that each interview is presented with the same questions in the same order. This, in turn, ensures that answers can be reliably aggregated and that comparisons can be made with confidence between sample groups or between different survey periods. Consequently, there is a common format, which makes it easier to code the responses, analyse and interpret the data. However, that does not preclude asking unplanned questions if the researcher thinks it is necessary to do so. Raised questions in structured interview could be closed-ended questions, so that the respondent is given specific options that he must be adhered to, or could be open-ended questions as well.

semi-structured interview: Also known as non-standardized interview, and is frequently used in qualitative analysis. In this type of interviews, the researcher can change the

order of questions depending on the direction of the interview. Moreover, this type of interviews do not depend on the use of specific questions in advance, where the interviewee has a general understanding of the subject, and they have not list of questions prepared in advance (Hussey, Hussey, and Hussain, 1997). One of the characteristics of unstructured interviews is the flexibility of the interview where you can modify or add questions during the interview. In addition, this type of interviews are used in most cases of exploratory research, where this research constitute a preliminary stage to conduct in-depth studies.

Unstructured interview: It has more relaxed rules than the other types of interviews. In this type, the researcher needs only a list of topics to be covered during the interview. There is no script and order, but interaction between participants and the researcher is more like a conversation than an interview.
Saunders, Lewis, and Thornhill (2003) mentioned that there is no need for a list of questions or themes in this type of interviews, but only a clear idea about the aspect or aspects that are required to be explored (Saunders, Lewis, and Thornhill, 2003). However, this type of interviews is most often used in ethnographies. They are best used when the researcher wants to find as much information as possible about their subjects, hence, the benefit of unstructured interviews is that they often reveal information that would not have been exposed using semi-structured or structured interviews. In addition, the researcher and participants are not limited by the protocol, however, unstructured interviews can only be used for qualitative researches (Dawson, 2002).

2.12 Questionnaire

The questionnaire is to help the researcher gather information needed for the research. It is very similar to the structured interview. However, the main deference between them is that the interviewer will not be attendant to read the questions but the respondents must read the questions and answer them by themselves (Bryman, 2001).

Questionnaire is one of the research techniques used widely in order to obtain data or information concerning the conditions of people, orientation or tendencies, and the importance of the questionnaire lies in being a tool to collect information economically with regard to time and effort spent when compared against observation. Moreover, questionnaire consists of a form containing a set of items that each participant should answer individually and without any intervention from others. On the other hand, there can not be perfect questionnaire composition to recommend for adoption for all conditions and situations due to the fact that every phenomenon has its specificities, nature and specific module, and only the purposes of research determines the form and content of the questionnaire. However, questionnaires work well with questions that are standardized and can be understood and interpreted the same way by all respondents (Saunders, Lewis, and Thornhill, 2003).

2.12.1 Type of questionnaire

Saunders, Lewis, and Thornhill (2003) has classified the questionnaire according to how it is administrated into two types:
Self-administrated, which is usually completed by the respondent. This kind of questionnaire is delivered and returned directly by Email, post, or hand.

Interviewer-administrated, which is recorded by the interviewer and it can be conducted by phone or by structured interview (Dawson, 2002). This type of questionnaire can be more classified, according to the sort of questions and required answers, into three types: closed-ended, open-ended or a combination of both.

Closed-ended questionnaire: Here, the answer may be restricted, where the questionnaire contains questions followed by specific multiple choices answers . The participant has to choose the answer by marking them (Kumar, 1999).

Open-ended questionnaire: In this one the answer is free and open. The questionnaire contains a number of questions that need to be answered by the participant in his/her own way. This type aims to give such an opportunity to write the respondents' opinions and excuses to answer fully and explicitly (Dawson, 2002).

A combination of both open and closed ended questionnaires: Many researchers tend to use a combination of both closed and open questions. In this way, it is possible to ask how many people use a service and what they think about this service in the same form. Many questionnaires start with a series of closed questions, with boxes to tick or scales to rank, and then ends with a section of the open-ended questions for more information (Dawson, 2002).

In this study, the questionnaire survey was designed in five sections. The first Section is an introduction to explain the concept and the purpose of the questionnaire, while the second section is about general information on the background of respondents which are known as demographic questions. These questions address the respondents' job, qualification, age, experience period and position in the organisation. Section three is addressing the TPM activities within LISCO. This section consists of twenty statements incorporating the 5-point Likert scale. Next, section four is about the opinion regarding factors affecting the success of TPM implementation and it consists of 60 statements which also incorporated the 5-point Likert scale. Further, section five is addressing the evaluation and rank of the factors affecting the success of TPM implementation.

According to Hussey, Hussey, and Hussain (1997), it is often possible to allow participants to give more discriminating responses by providing them with some forms of rating scale. In fact, one of the more frequently used types of scale is the 'Likert Scale'. This turns the question into a statement and asks the respondents to indicate their level of agreement with the statement by ticking an appropriate one.

In this study, the questionnaire is mainly based on a Likert's Scale of five ordinal measures (Figure 2.2) from one (1) to five (5) according to the level of agreement.

ranging from "Strongly Disagree (SD)" on one end to "Strongly Agree (SA)" on the other with "Neither Agree nor Disagree (N)" in the middle, passing through "Disagree (D)" and "Agree (A) in between".

FIGURE 2.2: Sample 5-point used in Likert scale questions.

2.13 Validity and Reliability

The aspects of the quality of any design, validity and reliability, must be maximized by the researcher of the case study according to (Yin, 1994). The research is characterized by validity when it measures what it has claimed to measure. For example, if the test is to measure the children's writing ability, then it must measure this ability. Nevertheless, if the result of the measurement has measured the ability to count and math, then this can not be characterized by validity. Validity is defined as the extent to which the instrument measures what it purports to measure and the information collected by the investigator truly reflects the phenomenon being studied. Validity refers to the quality and can be applied to any aspect of the research process (Kumar, 1999).

The research is characterized by reliability when it gives the same results or convergent results when applied more than once in similar circumstances. For example, If a test was used to measure a student's intelligence and received a 120-degree, this student should get the same result when offered the same test after two weeks or a month. Likewise, reliability is a common test used to establish the quality of any empirical social research where the operations of a study, such as data collection procedures, can be repeated with the same findings. (Yin, 2003), on the other hand, considers reliability is concerned about the last application of a study. If a later researcher followed the same set of procedures as described by the earlier researcher and conducted the same case study, the finding and conclusion would be the same. Reliability is aiming to minimise the errors and biases of the study.

Reliably and validity were the core concerns of this study. A triangulation approach which is combining the qualitative and quantitative approach was seen as an appropriate solution to increase the reliability and validity, therefore this study employed three research techniques (interviews, questionnaires, and document analysis), and gained data and information from different departments (maintenance, production, and TPM committee). In addition, the samples were selected from different levels.

2.14 Conducting the pilot study

The pilot study is the final preparation for data collection. When a study is conducted to determine its feasibility it is called a feasibility study or pilot study. (Yin, 2003) stated that the pilot case study helps investigators to refine their data collection plans with respect to both the content of the data and the procedures to be followed.

A pilot study gives an investigation of whether the questions asked are sufficient to generate the wanted information. Furthermore, it increases the validity of such questions in both questionnaire and interviews, as the researcher has a chance to rephrase and reconstruct the questions. Researcher believes that, conducting pilot study is of a high degree of importance in order to help estimating the appropriate time to conduct interviews as well as to ensure that questions are clear, accurate and relevant to the problem of search. According to Stake (1995), the data provided from the pilot study can be used to enhance the validity of questionnaires for the study and to ensure that it is easily understood and easy to answer (Stake, 1995).

The researcher contacted some engineers and workers inside the Libyan iron and steel company premises. Such activity is considered as a pilot study for the research.

Conducting this pilot study was for obtaining results from respondents who are working in the same industry 'steel industry', but different areas in criteria of design and process. The pilot study involved different levels of management and supervisors. The questions for the survey were designed and deduced according to the previous interview with the TPM Directorate Committee in LISCO. The questions also had been presented to some Libyan students in Coventry University.
The feedback and comments of conducting the pilot study are:

- Some questions were found to have the same meaning.
- Some questions were answered by other sources in the company such as reports documents, etc.
- Discussing the translation difficulties of some terms in Arabic.

2.15 Conducting the industrial case study

After identifying the case study and its units, an investigation of the TPM implementation will take place by adopting three research techniques (interviews, questionnaires, and document review). Data will be collected from TPM implementation committees, group of activity and TPM oversight committees. Where these committees consist of directors of operation departments, maintenance departments as well as members of the occupational safety and engineers from the development department. The small group of activity consists of operators and maintenance workers. Data will contain general information about the respondent like whether the respondent is an operator or maintenance personnel, the period of employment and the age of respondent. There are also data about the factors and obstacles that affect the success of applying TPM. Finally, data on the company's internal customer satisfaction rate and the intake of these regulations will be collected.

LISCO as a case study will be discussed later on chapter four.

2.16 Conclusion

Complete briefing of the adopted research methodology has been done in this chapter along with briefing about the main philosophy and explanation of the qualitative and quantitative approaches as well as justification for their adaptation. A reasonable explanation has been done for the adaptation of the selected case study research design has been done. The chapter, also, addressed indicated the sources used for the data collection. The chapter also briefed the methods adopted for generating the research questionnaires and interviews for conducting pilot research and case study.

Basically, this would help in getting an idea about how the research questions would be answered through the methods mentioned above and the adaptation of the method of case study, while considering the availability of the time. TPM would be brought under discussion with reference to the literature review in the next chapter to explain the concepts associated with it.

Chapter 3

Literature review

3.1 Introduction

Literature review is considered as an essential part of research as it contains a critical evaluation of the main issues of the research along the evaluation of all the factors associated with it in the light of the researches conducted previously.

This is an exploratory research and considering the nature of this research, the literature review is required for getting the main concept of TPM philosophy, principles, pillars and tools. The literature review, also, highlights the TPM within continuous process industry, and steel companies. Not only this, literature also helped in highlighting the factors that influence the implementation of TPM.

Basically, a theoretical framework was developed based on the literature and researches conducted previously.

3.2 Background

Due to the high capital cost of productive assets, it is natural, for those high-value assets, to perform the maintenance operation in the right way in order to prevent any damage and rapid end-of-life. Moreover, appropriate maintenance must be performed to all the organisation's assets without exception, and continuously. The problem in some organisations is that they might ignore the application of proper maintenance under the pretext of saving expenses to increase profits. Such companies adopt old traditional maintenance systems and emergency maintenance. When failures occur, the company losses incurred as a result of cessation of production, delaying orders for customers, and the loss of good opportunities to sell.

In order to keep the fixed assets of these enterprises, there must be a section for maintenance which should include the most efficient elements and the task of planning, preparation and implementation of maintenance programs so as to ensure to maintain and improve their machines' performance. Further, some big companies do beyond that, they apply a comprehensive system to deal with the equipment and the work place. A. Jain and Singh (2014) in study of Indian and non Indian companies, which has clearly show that companies are in dire need to foster the practice of TPM implementation to compete in the global market and the fluctuating demands of large-scale industries.
According to (Nakajima, 1988), the three terminology of TPM contain the meaning:
Total: The overall participation of all employees from top to bottom. All functions and all levels to maintain the performance of equipment efficiently and effectively.

Productive: To maximize efficient productivity, get Zero defects, Zero breakdowns, and Zero accidents.
Maintenance: keeping the equipment and all the assets in proper condition (Nakajima, 1988).

3.3 TPM Definition

The TPM is the short form of Total Productive Maintenance. Literature offers many variations on the same theme when defining a TPM. TPM is a US productive maintenance reformed and enhanced to suit Japanese companies (Nakajima, 1988). Nakajima (1988) mentioned that the definition of TPM by Westerns focuses on Overall Equipment Effectiveness (OEE), while the Japanese focuses on Small Group Activities (SGA) (Bamber, Sharp, and Hides, 1999). Furthermore, TPM was defined as a maintenance program that covers all the company aims to reform the roots of the equipment and human resources problems and to reduce the losses of equipment which includes stops, poor efficiency as well as defects, in addition to improving the overall effectiveness of equipment. Robinson and Ginder (1995) said that "TPM is a complex, long –term process which must be sold to the workers as a legitimate improvement methodology". Further, TPM was defined as an innovative maintenance to maximize the effectiveness of the equipment, eliminate breakdowns and disseminate of the concept of autonomous maintenance by the operator in the daily work for all employees in the company. Likewise, TPM is a strategy carried out by all personnel who are engaged directly with manufactures to achieve zero accidents, zero defects and zero breakdown (Tajiri and Gotoh, 1992).

Likewise, Nakajima (1988) defines TPM "Total Productive Maintenance (TPM) is productive maintenance involving total participation of all employees through small group activity in addition to maximising equipment effectiveness and establishing a thorough system of a comprehensive planned maintenance system".

Cooke (2000) has another definition "TPM seeks to engender a company-wide approach towards achieving a standard of performance in manufacturing, in terms of the overall effectiveness of equipment, machines and processes, which is truly world class". Besides, Bill and Maggard (1992) states that "total productive maintenance is a new work system that addresses the interface problems between a company's maintenance organisation and its production organisation" (Bill and Maggard, 1992). He also defined TPM as "complementary with total quality management (TQM), JIT, total employee involvement (TEI), continuous performance improvement (CPI), and other worldclass strategies" (Bill and Maggard, 1992). Even more, Hartmann (1992) cites "total productive maintenance permanently improves the overall effectiveness of equipment, with the active involvement of operators" (Hartmann, 1992). Further, Suzuki (1992) pointed out that TPM is a joint effort to help firms grow by engaging everyone from senior to plant-floor (Suzuki, 1992). Moreover, Willmott and McCarthy (2001) said "TPM is a Japanese management protocol developed to alleviate production losses caused by machine breakdowns" (Willmott and McCarthy, 2001).

In fact, the most common definition that introduces TPM as a maintenance technique carried out by every single employee from the top management to plant-floor through

small group activities, is the Japanese Institute of Plant Maintenance's (JIPM) definition that defined TPM to include the following five key elements (Pomorski, 2004):

1. TPM aims to maximize equipment effectiveness.
2. TPM establishes a comprehensive preventive maintenance (PM) system.
3. TPM can be implemented by all departments that use and maintain equipments.
4. TPM involves every employee from top level to the workers on the shop floor.
5. TPM is based on the promotion of preventive maintenance through the motivation of management and autonomous Small Group Activity.

Next, TPM history is narrated.

3.4 TPM history

The TPM philosophy was derived from quality concept which was taught to the Japanese by the American expert Dr. Deming (McGee, 2007). While the Japanese were developing the concept of Quality Control through statistical analysis, they found that there is a need to go further than preventive maintenance to improve equipment efficiency and this need introduced TPM philosophy as a complementary system to quality concept. 'Seiichi Nakajima' is known as the Godfather of TPM, Who explored it in Japan and called the Japanese Companies to practice this new direction of production (Willmott, 1994a).

On the other hand, McGee (2007) referred that the unique Japanese method called TPM was born in the fabrication and assembly industries. However, when TQM became well known in Japan, it took place in plant maintenance and Japanese industries were investing increasingly in new equipment to become more automated and less workers concentrated. Whilst, the process industries were concentrating on preventive and productive maintenance (Figure 3.1). In this way, Japan became the world leader in using the robots in their industries. This development in the automation has brought

FIGURE 3.1: From preventive maintenance to TPM.

a trend toward some manufacturing techniques and improving maintenance management, which gave birth to the TPM. In the same contect, McGee (2007) said that TPM is a Japanese equipment management strategy created to back up the TQM strategy. It is a practice that deals with maintenance environment in those companies which were

undertook by TQM. On the contrary, Hartmann (1992) believed that the Japanese imported preventive maintenance (PM) from America in the 1950's. They took the idea and developed it to become TPM. This scenario has occurred before with TQM and other productivity techniques.

In fact, TPM gradually evolved from the 1950's to the 1970's and started with US preventive maintenance and then focused on the productivity and reliability of maintenance. During that time, data related to these practices were collected and fedback resulting in new preventive maintenance through comprehensive regime based on collaboration between all employees. However, Robinson and Ginder (1995) argued that "TPM does not belong to any one country". In fact, Wireman (2004) mentioned that in the 1970s the Japanese improved the preventive maintenance program to become a strategy established a thorough system of preventive maintenance by everyone in the organization. After that, the Japanese started separating their TPM system widely.

Importing some manufacturing techniques and philosophies such as TPM could help the organization to maintain the existing equipment instead of importing new ones, where such techniques may make the machines at great condition of performance for a long time. The first countries imported TPM system from Japan were the Southeast Asia countries by virtue of geographical location (Nakajima, 1988). It is worth mentioning that Nippondenso is one of Toyota group suppliers, and was the first user of the term TPM in the late 1960's. The group won The PM prize from Japan Institute of Plant Maintenance (JIPM), which was the first prize gained for the successful implementation of TPM (Robinson and Ginder, 1995). Moreover, Volvo Company in Belgium is one of first non-Japanese winners of PM prize.

In fact, TPM method and its improvement activities were applied at the beginning exclusively in some departments that were directly in touch with the equipments (Suzuki, 1994). Whereas, the other departments were supporting TPM to increase the productivity. Then, after a while, these departments also became appliers of the system to improve their effectiveness and efficiency. Furthermore, TPM technique was also adapted in departments other from those that have machinery and equipment, and was called company-wide TPM.

Further, Nakajima (1988) confessed that TPM is a US productive maintenance reformed and enhanced to fit Japanese companies. On the other hand, the development of the preventive Maintenance (PM) in Japan was established between 1950 and 1980, which can be illustrated in Table 3.1 (Nakajima, 1989). Also, Nakajima stated that there is a relationship between Total Productive Maintenance (TPM) and Zero Defects (ZD), as they both aim to eliminate defects. Furthermore, TPM strives to eliminate the six big losses which corresponds to the aims of Toyota Production System (TPS). Equally important, one of the main goals of TPM is maximizing the performance of equipment which partially meets terotechnology and logistics aim of achieving an economic life cycle cost.

TABLE 3.1: Development of TPM in Japan (Nakajima, 1989)

3.5 Types of maintenance

Since the 1970's, maintenance has witnessed changes perhaps more than any other management discipline. These changes are the result of a massive increase in the number and variety of physical assets (plant, equipment and buildings), which must be maintained in all parts of the world, in addition to more designs and maintenance techniques. Moreover, these changes are the result of the change in maintenance responsibilities and views on the organisation.

Since the 1930's, the development of maintenance can be classified over three generations: the first generation covered the period up to the second World War, where in those days a very simple and light machinery were used and maintenance was fairly easy and hence there was no need for programs and maintenance systems, but rather just some routine cleaning, oiling and lubricating. However, during the second world war, things changed dramatically as the demand for good of all kinds was increased in the wartime, while the supply of manpower decreased sharply, and consequently, this led to the necessity of mechanisation. In the 1950's, machines were more complex and more numerous which led in turning to the preventive maintenance approach. As a result, a rise in the cost of maintenance and relative operation costs were evident, the matter that led people to start searching for ways that could maximise the life of the assets. Finally, since the mid-seventies, the processes of change in the industry has gained significant momentum that can be categorized under the headings of new expectations, new research and new techniques and this was the third generation.

It is also important to mention that the downtime always affect the productive capacity of the physical assets leading to the reduction of production, increasing of operating costs and interfering with customer service. Moreover, the increasing cost of stock led to reducing the stock levels and moving towards the just-in-time systems which make the minor equipment failures have a major affect on all kinds of logistics support. However, industry in general is devoting a great attention to doing maintenance job properly (doing the job right), while much more needs to be done to ensure that works which are being planned are the works that should be planned (doing the right job). The main challenge facing the maintenance people at the present time is not only to find out what are the suitable techniques, but to decide which are worthwhile and which are not in their organizations. If the right choice is made, it is possible to improve the performance of the assets while at the same time contain and reduce the maintenance costs. Instead, If wrong choices are made, new problems will be created while the existing problems will worsen (Moubray, 1997).
Types of maintenance are listed below (Venkatesh, 2007).

1. ***Breakdown maintenance***: In this type of maintenance, no care is taken for the machine until equipment fails and repair is then undertaken. When the repair cost is the only cost that is incurred, this type of maintenance is usually applied. It is also favoured in the case when there is no stoppage in the operation and production (Narender and Gupta, 2012).

2. ***Preventive maintenance***: The day to day maintenance of equipment and machineries for their deterioration prevention and periodic inspection is referred to as preventive maintenance. One can say that it is the stitch in time sort of maintenance which is done to keep it running efficiently and avoid any further possible damage to the equipment in future. This enables the owner to extend the

service quality and life of the machine. (Narender and Gupta, 2012). It is defined also as the preventive maintenance on a scheduled basis to ensure the continuous smooth operation of equipment (Steinbacher and Steinbacher, 1993).

3. ***Periodic maintenance (time based maintenance - TBM)***: As discussed earlier, it refers to the repeated checking, cleansing and servicing that is conducted to keep the machine working and free from any unwanted future issues. E.g. replacement of coolant or oil every 15 days (Narender and Gupta, 2012) (Mostafa, 2004).

4. ***Predictive maintenance (condition based maintenance - CBM)***: Based on the current condition of the important, and generally the useful, parts of the machinery and equipment, their overall life duration is analyzed and predicted. This is called predictive maintenance, Furthermore corrective measures are taken to ensure that the equipment works efficiently. It is relatively hi-tech in nature with the adaptation of the surveillance system to get first hand information via online systems (Narender and Gupta, 2012). The predictive maintenance is to determine the life expectation of equipment (Steinbacher and Steinbacher, 1993).

5. ***Corrective maintenance***: Corrective measure refers to the corrective tasks that are conducted in order to shape up and make the equipment suitable enough that when preventive maintenance is carried out, it works optimally (Narender and Gupta, 2012). This happens at the equipment user's level e.g. installing a guard, to prevent the burrs falling in the coolant tank. This kind of maintenance is used to improve equipment performance (Steinbacher and Steinbacher, 1993).

6. ***Maintenance prevention***: Maintenance prevention program point towards the issues that are present in the current machine and how the same can be removed to prevent defects. The issues are studied rationally while the data collected and analysed is usually provided to the makers and manufacturers of the machinery to ensure that the same problems in the equipment designs are not repeated in the future production (Venkatesh, 2007)(Narender and Gupta, 2012) (Mostafa, 2004). Maintenance prevention must be used in the design and selecting of new equipment (Steinbacher and Steinbacher, 1993).

3.6 Continuous process industry and lean

The process by which specialized products or specialized parts of the equipment are developed is known as discrete manufacturing. Under this system, specific parts like engine or house hold kitchen appliances are manufactured. The aspect that is associated with discrete manufacturing is that the number of items made can easily be counted. On the contrary, continuous manufacturing or the process industry refers to that manufacturing which cannot be counted but measured.

The type of products coming under the continuous manufacturing includes textile, steel, fluid goods, glass, oil and flour (Needy, 2000). Both of these classes of manufacturing, continuous and discrete, are termed as the manufacturing systems. These manufacturing systems engulf the complete manufacturing industry. Within the continuous manufacturing industry processes, the Lean improvement efforts tend to be limited (King, 2009). There are no data or any rational recordings available to analyze the innovating efforts made, although it was extremely successful in the industry where, however scarce, Lean process was laid into action over the past two decades.

The human psychology of resisting change can be termed as the major reason for its lack of complete implementation in the industry. Visionary leadership that are ready to accept the change can help in providing the impetus. It is, however, important to note that continuous manufacturing might be requiring its specialised version of Lean (Floyd, 2010).

The characteristic feature of the continuous manufacturing is that it is in line with the inflexible process where large quantity of volume is generated with lesser variation. Therefore, Lean process is of significant importance in such industries like those of electrical products, but mostly in the automobile industry. This is also true because there is little variation while coming up with the main design and interior of the vehicle. Thus, most of the present corporations in the automobile industry paved way for the application of lean into their manufacturing processes. The leniency shown by the corporations while adopting the Lean is because of its presumed inflexibility. This is also true when frequent distinct changes are needed to be incorporated in short bursts since the process industry cannot afford to stop to adjust for the minor adjustments and therefore corporation find it a costly bargain to adopt the lean process. Shafeek (2012) said that higher productivity in a very modern continuous process industry such as a cement factory is rely on regular, scheduled maintenance. This required planning, to ensure that always the company's employees hve the knowledge, manpower and parts on hand to give equipment they need when it is due to scheduled maintenance (Shafeek, 2014).

Although both the discrete and continuous manufacturing has many commonalities but the major difference of the continuity of the production tends to be the major hurdle in adoption of lean process within the process industry. Here, the corporation consider that halting the process of continuity production would lead to excessive and irrational expenditure. Regardless of all the commonalities and overlapping between the two manufacturing types i.e. discrete and continuous, there also exists a wide marked gap between the two as well. However, the productive maintenance can be applied to continuous manufacturing as well and then it can be analyzed rationally to evaluate their benefits. Although the process and discrete industry share several common characteristics, there are areas where they are very different. Both manufacturing settings have overlapped, but at the extreme, each has its unique characteristics. The next section gives some features of process industries.

3.7 Special features of process industries

Certain unique features and concerns distinguish process industries from the discrete industries where the TPM was born.

- ***Diverse production system***: A diverse production system refers to the concurrent application of both the manufacturing styles in the same plant. This is because the process industry generally relates to the substances like glass, cement, oil and paints or those products that are continuous in nature and cannot be measured. However, when it comes to product diversification or implementation and application of variety in the same or even production in lesser quantity both the manufacturing system may work in tandem.

- ***Diverse equipment***: Different unit operations are conducted in process industry. The products made in this industry generally include appliances and small machineries. The combination of all these unit operations results in the continuous production of the products. These methods may include processes like filtration, concentration to moulding, drying and even transportation.

- ***Use of static equipment***: TPM activity is required in those equipments which correspond to special nature. One of their key aspects is that these are static equipment. To avoid any blockage, disruption, leakage and corrosion TPM techniques are employed to ascertain that product quality and process conditions match with each other.

- ***Centralized control and few operators***: The characteristic feature of the continuous process manufacturing is that it employs less operators and focus more on being centralized control. Since all the systems are integrated, it ensures that all the systems are centrally controlled with less number of employees involved.

- ***Diverse equipment-related problems***: Equipment-related different issues also crop up. There are very common ones including the usual leaks, blockages and corrosion. However there are other problems as well including parts falling off, overheating, burning, distortion etc.

- ***High energy consumption***: Standby units and bypasses are used to diminish the effects of the different breakdowns that may be characteristic of the process industry. This is because most of the processes involved in this type of manufacturing require high heat and energy consumption. Different types of fuels and energy is used in the said processes which also lead to accumulation of heat energy.

- ***High accident and pollution risk***: Statutory regulation are strictly implemented and practiced in case where toxic material is being used in the process of manufacturing of different products to avoid any mishap from happening. This may result in unwanted pollution and explosions. Factories are designed in such a way to minimise their effect. High pressures and high temperature may also increase the risk of the accident within a company at risk.

- ***Poor working environment***: Equipment problems also come up due to poor sanitary conditions and cleanliness within the company. During manufacturing process different intermediaries are likely to come out of the process. These may include toxic substances to benign liquids. All of these add to the working environment. It is only mandatory to ensure that working environment remains healthy and clean.

- ***Shutdown maintenance***: One of the costly and time consuming aspects within the process industry is shutdown maintenance. It does not only require continues services of at least an employee, but also requires time to take place properly. The shutdown maintenance helps the equipment and machinery within a company to prevent breakdown and hence any possible monetary and production loss. It should therefore be practically, rationally and carefully planned and designed to ensure its effective implementation. The cost, benefit and losses should also be assumed before hand (Suzuki, 1994).

3.8 TPM and Steel industry

ArcelorMittal is the world's leading mining and steel company. In April, 2008, the downstream units of ArcelorMittal Liège in Belgium, won the TPM Excellence Award. This Japanese award offers recognition of the reduction in accidents and absenteeism and the high proportion of deliveries made on schedule. The success of the units' performance is based on the rigorous methods of the TPM. At ArcelorMittal, TPM provides the methodology for successfully gaining this by applying the eight pillars. In an initial TPM phase, ArcelorMittal Gent gave priority to the first four. The key goal of industrial companies at the present time is to achieve a competitive advantage. This competitive advantage due to decreasing costs and increasing work efficiency, and customer-orientation processes. Changing circumstances and boosting demands on the part of the customer requires new ways to manage production. Methods like Total Productive Maintenance TPM gained popularity in the steel industry in the past few years (Gajdzik, 2009).

The TPM program in the rolling and coating units at SSAB Tunnplåt in Borlänge is unique in Swedish heavy industry environment – both as regards the amount of resources and how the TPM program has been implemented. At its peak, 29 people were working full time on the program. The long-term aims to introduce maintenance by operators and, in the short term, to create background and conditions that will make this possible. Another important objective is to boost the participation of the production personnel and to improve their knowledge of their equipment. The expected result will be higher availability, plant utilization and quality. This will be gained by a multitude of activities, the purpose of which is to change attitudes and this, in turn, will boost involvement. This will put to use the broad competence and knowledge of the employees.

The TPM program has contributed to the environmental work at SSAB Tunnplåt in Borlänge by means of such as a proposal being drawn up for a standard for sorting at source and for environmental stations. Other activities include all oil leakages found and sealed, and all clearance carried our during major cleaning. As an example, 18 tonnes of oily rubbish have been recovered during cleaning at the coiler and stands 1–6 in the hot strip mill. The TPM project has also been presented outside SSAB Tunnplåt in the form of both lectures and articles in publications. The SIAM UNITED STEEL (SUS) was established in 1995, it had adopted TPM activity since 2005. SUS received the award for TPM excellence category A 2008 from The Japan Institute of Plant Maintenance (JIPM).

TPM implementation activities was adopted in the Indian industry and to highlighting the achievements of Indian companies through strategic TPM initiatives. They succeeded to implement TPM as a strategy and culture for improving the manufacturing performance.

TPM initiatives in the steel industry have been elaborated to achieve the tangible and intangible benefits accrued as a outcome of successful TPM implementation (Aspinwall and Elgharib, 2013). The approach has been directed toward justification of TPM implementation for its support to competitive manufacturing in the context of Indian manufacturing industries (Narender and Gupta, 2012). Many Indian steel companies implemented TPM successfully, and they won TPM awards, for example Tata Iron

Steel Company Limited. Four units of Tata Iron and Steel Company Limited have been adjudged winners of the 'TPM Excellence Award - 2004' by the Japan Institute of Plant Maintenance (JIPM). A. Jain and Singh (2015) in Pipe factory case study, which has adopted the TPM and got improvement in productivity by reducing downtime. Availability, performance, and quality and OEE rate increased as a result of adoption of the new maintenance concept. furthermore, he said before implementing TPM, the OEE of all the machines was less than 50 percent and after the implementation it rose to about 70 percent. El-Dikheila Steel is an Egyptian steel company, that was established in 1976. In order to increase plant efficiency and gain Competitive Advantage, a new maintenance philosophy pursued by the company. Starting with preventative maintenance, then introducing condition based maintenance (CBM) and eventually applied total productive maintenance (TPM) concepts, the company has enhanced its maintenance systems considerably in the last few years. To improve productivity, safety, plant availability and product quality, the company has instituted quality control circles whose recommendations are often put into practice.

3.9 TPM Organisation Structure at Process Industries

The organizational structure for implementing TPM, which brings together people from different areas of activity multidisciplinary appropriately. The organizational structure of TPM at the company was evolved carefully for planning and implementation and support initiatives of TPM at all levels. The key point for the development of TPM was formed and a problem-solving teams and equipment was prepared to improve the effective operators for the front line in the shop floor. These teams consist of small groups comprising of 5 to 7 workers , led by a supervisor. All manufacturing lines in the factory was 5 to 8 teams for the effective application of the activities of TPM. These teams worked under the direction and supervision of foremen TPM promotion committee, which consists of the leaders of these teams. This committee was headed by a line in charge as shown in Figure 3.2. The foremen TPM promotion Committee used to control the line (Ahuja and Khamba, 2007).

The organisation structure has a key feature that there was considerable overlap between the different groups which indicates that there was a synergy between the full operations. TPM secretariat was responsible for the effective management of the activities of TPM. It contains sub-committees at the plant level for each TPM pillar, such as focused improvement, autonomous maintenance sub-committee and so on. Robinson and Ginder (1995) said that sub-committees are used to support the promotion committees (Robinson and Ginder, 1995). TPM is promoted through a structure of overlapping small groups. In this system, leaders of small groups at each organisational level are members of small group at the next higher level. Top management itself also constitutes a small group. Also, TPM office should be run by permanent full time staff helped by all different committees and subcommittees (Suzuki, 1994).

3.10 Development of the theoretical framework

This research offers a framework based on the literature review. Furthermore, it focuses on the evaluation of the TPM system and how the maintenance activities within a company are associated with it. Another important issue addressed, was the change management and how it is needed to be considered by the manufacturing companies. If the company manages to develop a relation between maintenance and quality, then

FIGURE 3.2: TPM Organisation Structure (Suzuki, 1992).

they would be able to integrate it within their production procedure, hence TPM can be considered as a strategy for change within a company.

The elements of the framework mainly are: Pillars, Foundations, Aims, Effectiveness, TPM factors, and TPM techniques. Figure 3.3 shows the framework and the link between all these components of this framework.

3.10.1 TPM Aims

TPM is seeking to maximize the effectiveness along the life cycle of the equipment. It struggles to maintain the equipment in optimal condition in order to prevent unexpected collapse of the equipment or the loss of speed. There are three aims of TPM: zero breakdown, zero defect, zero accident (Nakajima, 1988) (Willmott, 1994b). It can be observed through the literature review that the implementation or adaptation of TPM is a complicated task and has a number of complex factors associated with it that limit the implementation of TPM in some ways. Certain models and frameworks have been developed by some authors that highlighted the concepts and principles of TPM and its implementation.

3.10.2 TPM Foundations

The main features of TPM are the pursuits of economic efficiency or profitability, improve maintainability, maintenance prevention, and use of preventive maintenance, and full participation of all employees. Achievements include the bottom line of successful initiatives in the implementation of TPM organization's low operating costs, and longer equipment life and reduced maintenance costs in general. TPM, thus, can be described as a structure of equipment-centric continuous improvement which strives to improve production effectiveness through the identification and removal of equipment and production efficiency losses throughout the life cycle of the production system through team-based participation of workers at all levels in the organization (Ahuja

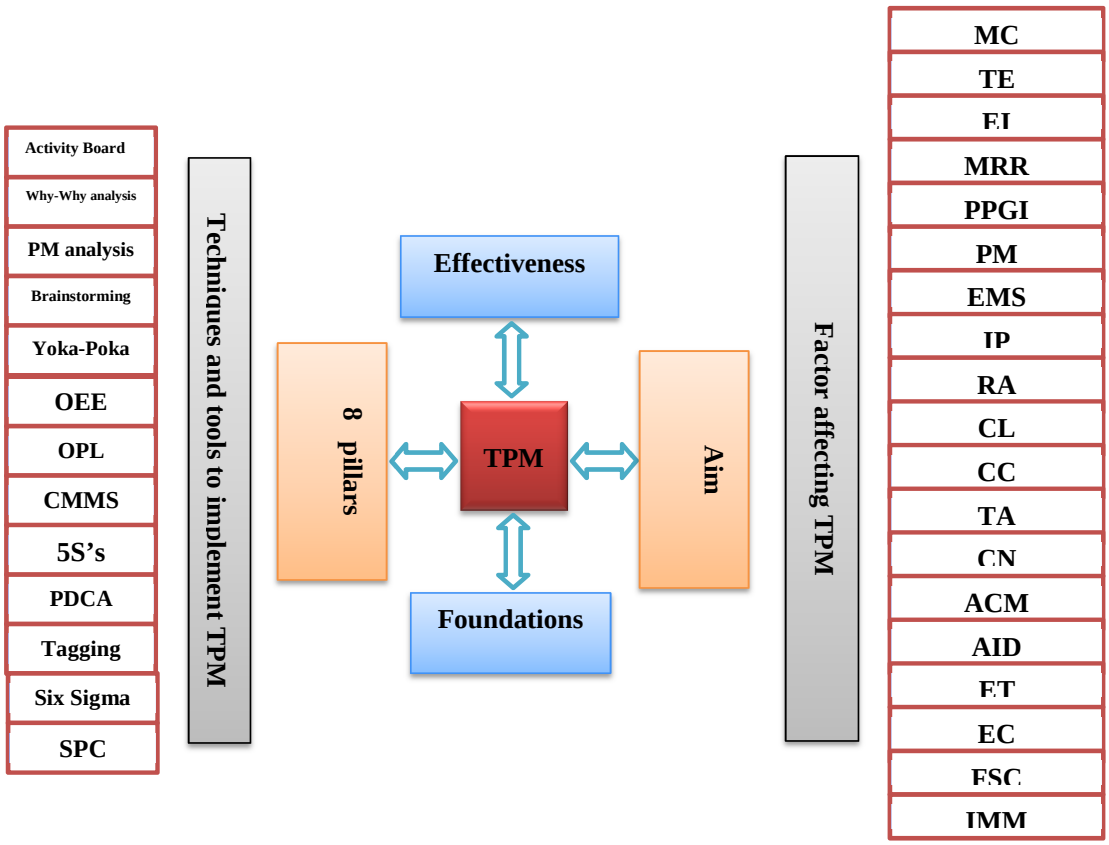

FIGURE 3.3: The theoretical framework.

and Khamba, 2008c).

According to Suzuki (1994), in 1989 the JIPM introduced a new meaning of TPM after its wide expend throughout many organization in many pre-production including product development department as well as sales and administrative departments. This definition is based on the following strategic components:

1. Building a corporate constitution that will maximize the effectiveness of production systems.
2. Using a shop-floor approach that prevents every type of loss.
3. Involving all departments in implementing TPM, including development, and administration departments.
4. Involving everyone from top management to shop-floor workers.
5. Conducting zero-loss activity through overlapping small-group activities (Suzuki, 1994).

Companies that implement TPM achieve higher productivity and better quality, in addtion to meeting customer requirements and expectations, waste elimination and reduce delays in processing customer orders (Arashpour, Enaghani, and Andersson, 2010). Similarly, Gajdzik (2009) said there are competitive advantages as a consequence of low costs and high work efficiency and customer-oriented operations which is the

main aim of TPM. Furthermore, TPM may be considered as an improvement project with the goal of decreasing process delays and involving operators and maintenance personnel, providing internal and external customers with fewer defective products and positively affects flow and perfection. Moreover, TPM is much more about safety, usability and utilization of assets, increasing capacity without investing in new equipment or people and of course, continuing to reduce the cost of maintenance and improve machine uptime. Finally, TPM implementation demands long-term commitment to obtain the benefits of enhanced equipment effectiveness through management support, training, and teamwork (Ahuja and Khamba, 2008c).

3.10.3 TPM Eight Pillars

The key elements of TPM are known as "pillars" and sometimes they are called activities (Ahuja and Khamba, 2008c). The naming and the number of the pillars are slightly different from author to author, however, they all based on Nakajima's TPM pillars. Accordingly, each company that intends to apply the maintenance starts the application of these pillars as commensurate with its status. Mishra, Anand, and Kodali (2008) had discussed about TPM pillars as elements of TPM frameworks and said that the literature of TPM have listed a large number of them proposed by different consultants and authors. Most of these frameworks were developed by consultants based on their consultancy experience with different organisations. These frameworks were studied and it was found that just few frameworks are unique while in others, the naming and the number of pillars differ slightly (Mishra, Anand, and Kodali, 2008).

In accordance with the assessment criteria of Japan Institute of Plant Maintenance (JIPM) depends on the category of the reward. Companies that have introduced TPM and are applying for TPM award, they must achieve eligibility and requirements for each category. The main two eligibilities include deployment activity based on the five pillars of TPM and focusing on the production site (individual improvement, autonomous maintenance, planned maintenance, education and development, safety, sanitation and environment control) for category B. The second eligibility is deploying activity based on the eight pillars of TPM by all staff members of the plants (individual improvement, autonomous maintenance, planned maintenance, initial management, quality maintenance, administrative and supervisory department, education and development, safety, sanitation and environment control) for category A (JIPM, 2010).

As a result of these classifications, it was evident that worldwide companies fulfilled at least five pillars and in some cases went beyond the original Japanese model by building additional customized pillars (Cigolini and Turco, 1997). According to Davis (1997), cited in Bamber, Sharp, and Hides (1999), the successful implementation of full TPM pillars needs to allow sufficient time.

The Japan Institute of Plant Maintenance (JIPM) classified the TPM activities to eight pillars as follows (Figures 3.4 & 3.5):

1. ***Focused Improvement (Kobetsu Kaizen)***: Focused improvement it is also referred to as (FI), it includes all activities that aim to maximize the overall effectiveness of the equipment (OEE) and the overall efficiency of the plant (OEP) through fighting all the causes of losses and eliminating them permanently, and, also, the achievement of the zero proportion in losses in all activities and reducing costs and improving performance. The term Kaizen consists of two words "Kai" which means change, and "Zen" which means to the better, and the term "Kobetsu which means focused. So, focused improvement means all activities that

FIGURE 3.4: The TPM eight Pillars (Ahuja and Khamba, 2007).

maximize the equipment effectiveness through the complete elimination of losses and enhancement of performance (Nakajima, 1988).

2. ***Autonomous Maintenance (Jishu Hozen)***: It is also referred to as (AM). It means that the operators do some minor maintenance for their own equipment such as inspection, lubrication, and cleaning. It is a unique feature of TPM done by operators. In order to implement autonomous maintenance correctly, the seven steps' approach and the 5s are recommended (Nakajima, 1988). The implementation of Autonomous maintenance takes place after conducting operator training and rehabilitation in order to be able to perform some basic maintenance tasks for the equipment and to keep them under good operation condition as well as to prevent any deterioration of the equipment. The training also includes performing the daily routine maintenance work and knowledge of some simple repair works. This will make the workers able to identify faults and eliminate them without having to stop work and wait for long periods for the technicians. Therefore, autonomous maintenance is a self-maintenance efficient approach that depends on the level of training and capabilities of workers who operate the equipment, also it needs a degree of cooperation between different sections and departments of operation and maintenance.

3. ***Planned Maintenance (Keikaku Hozen)***: It is also referred to as (PM). It means maintaining the equipment to have defect free products and high plant availability (JIPM, 2010). It also means implementing the maintenance work through

FIGURE 3.5: Detailed TPM Pillars (Ahuja and Khamba, 2007).

planning, control and organising the information related to maintenance activities, including methods, materials, labour and the required times. The aim of planned maintenance is to ensure equipment performance at its best with a minimum of maintenance costs and enabling equipment to work at an optimal level at all times.

4. ***Quality maintenance***: It is also referred to as (QM). It means maintenance focusing on tasks that keep machines producing quality and defect-free products based on the basic idea that says maintaining perfect equipment to maintain perfect quality of products, and hence ensuring all operations run at a consistent level of quality (Venkatesh, 2007). The JIPM defines quality maintenance as the creation of conditions which prevent defects in the product and control these circumstances to get to the stage of zero defects.

5. ***Training and Education***: It is also referred to as (TE). It means improving the abilities of individuals to be multi-skilled employees (Venkatesh, 2007). Education and training aims to provide operators with different skills so that they can accomplish all the tasks required of them very effectively and independently. The operators may not understand the main operating principles of the equipment, and also the maintenance crew may not know some of the modern methods of maintenance, so it must include training on the basic requirements for the maintenance of overall productivity, and improve the skills of all employees in the field of maintenance.

6. ***Early equipment and process management***: It is also referred to as Maintenance prevention (MP), it is also known as early management (Suzuki, 1994). It is improvements to the equipment before normal operation can begin as part of a comprehensive approach to maintenance prevention and maintenance free design which is performed by production engineering and maintenance personnel (Nakajima, 1988). Early equipment management aims to develop a new design of the equipment, so that it works to reduce maintenance to a minimum or eliminate it, so, in general, that enhances the competitiveness of the organization. The early equipment management to develop the maintenance systems and the introduction of the concept of quality maintenance during the design phase, in order to improve the operational reliability of the equipment. The new design can be made to the current equipment, so that they can produce new products in high quality, through cooperation and coordination between the manufacturer of the equipment, engineers and specialists in the organisation (Robinson and Ginder, 1995).

7. ***Safety, health, and environment***: It is also referred to as (SHE). It means focusing on the workplace and surrounding area's safety to achieve an accident free workplace. Nakajima (1988) "Ensuring equipment reliability, preventing human error, and eliminating accidents and pollution are the key tenets of TPM". This pillar of total productive maintenance confirms that all the improvements which have been developed in the organization by the rest of TPM pillars do not diminish the overall performance of safety, health and environment criteria in the organization (M. M. Jafari and Ghavam, 2014).

   It also confirms that the actions and resources used to make substantial improvements in the performance of the manufacturing process are also in place to make similar improvements in the field of safety, health and environment. TPM is interested to preserve the safety, human health and the environment by providing a safe working environments free of the causes of accidents, injuries and occupational diseases (Narender and Gupta, 2012).

8. ***Office TPM***: It is related to the activities that improve the efficiency and effectiveness of logistic and administrative functions (Pomorski, 2004). Implementing total productive maintenance not only in the field of production, but also applied in the administrative work of the organization in order to get rid of losses and to improve productivity and efficiency in administrative jobs and tasks as well as to diagnose and remove losses. This includes the analysis of processes and procedures. All the problems and losses in administrative work must be eliminated or minimised to a large extent. There are losses in communication, disruption of office equipment, breakdown in communication channels, losses of time spent in data retrieval, and expenses purchases or emergency shipments (Narender and Gupta, 2012).

3.10.4 Effectiveness of TPM

Total Productive Maintenance has been practiced and examined for a period of time in many factories worldwide and most of the results indicate that it has worked well (Davis, 1997). Also, the benefits of implementing TPM are ten times more than the costs incurred (Suzuki, 1992).

In fact, the correct application of TPM will increase productivity, raise morals, save energy and increase job satisfaction for workers. Tajiri and Gotoh (1992) mentioned that the actual targets of TPM are fixed more concretely in terms of Production, Quality, Cost, Delivery, Safety and Morale (PQCDSM)(Tajiri and Gotoh, 1992). On the other hand, Wireman (2004) indicated that the average cost of conventional maintenance is about 28% of the total production cost, and the average of the technicians' actual work is about 2-3 hours per day in the companies that relies by about 50% on reactive maintenance , while they spend the remaining time involved in non-productive activities. Whereas, The TPM program puts the maintenance function at the centre of attention as a vital and essential part of any project, which is no longer seen as a non-profit function but considered in the development of the production scheduling and maintenance and has become in many cases an integral part of the productivity process itself.

Practicing TPM tasks can significantly enrich the operators work, gives them new experiences, strengthens their skills, and generates a feeling of property and ownership (Suzuki, 1994). Hence, TPM program is not just a production strategy, but a new philosophy of continuous development and collective action which creates a sense of ownership among the employees at all levels and the assets of the company and creates new directions for their commitment and responsibility. The idea behind implementing TPM is not just for achieving a zero defect product, zero breakdown, and zero accident for a period of time, but about how to keep this rate of achievement as long as the organization is working. The benefit of TPM can be divided into tangible and intangible benefits.

Tangible benefits:

1. Increase in overall equipment effectiveness (OEE).
2. Reduce the life cycle cost of equipment.
3. Eliminate unplanned downtime.
4. Minimise planned downtime.
5. Increase customers' satisfaction and decrease their complains.
6. Reduce the manufacturing cost (maintenance and production).
7. Reduce accidents and scraps.

Intangible benefits:

1. Improve in the ideas submitted.
2. Employees' confidence level went up.
3. Employees get the feeling of machines' ownership.
4. Working as a team cheers the employees up.
5. Sharing the experience.
6. Clean workplace provides psychological comfort.
7. Job enrichment.

TABLE 3.2: TPM pillars and their supporting tools (Jostes and Helms, 1994)

3.11 TPM supporting tools

Based on literature review of implementing TPM and its activities, it is noticeable that there are many instruments supporting the implementation of TPM and helping to unleash full potential of TPM pillars (see Table 3.2). As other lean manufacturing techniques, TPM integrates with the developed and proven maintenance strategies and it borrows techniques and tools from other disciplines. These tools are briefly defined as following:

- The overall equipment effectiveness (OEE) is a method to measure TPM success (Jostes and Helms, 1994).
- The 5S's (sort, set in order, shine, standardise, sustain) are tools to improve workplace environment (Nakajima, 1988) (P. S. Poduval and Raj, 2015).
- The statistical process control (SPC) is the use of statistical techniques to analyze a process and its outputs to improve the capability of the process (Jostes and

Helms, 1994). The SPC and the Computerized Maintenance Management System (CMMS) are a data collection and analysis tools (Pomorski, 2004).

- The six sigma is a tool that provides the structure needed to ensure the equipment is working optimally. It means that it brings possibilities identifying, qualifying and eliminating the activities that does not bring benefits for defining the new work standards (Szewieczek, Roszak, and Helizanowicz, 2008).
- The visual control (VC) gives an early warning signal and indicates the correct position of equipment gauges (Leflar, 2001).
- The plan, do, check, and act cycle (PDCA) is tool to drive TPM program to affect enhancement in the maintenance function (Ahuja and Khamba, 2008c).
- Poka-yoke (mistake proofing) is a key tool to eliminate defects and accidents (Szewieczek, Roszak, and Helizanowicz, 2008).
- Problem solving techniques are those techniques that use to get to the root cause of the problem, for example, brainstorming, fishbone diagrams, why-why analysis, and the 5m approach (Jostes and Helms, 1994).
- PM analysis consists of the following: define the problem; proceed with physical analysis; list the conditions causing the problems; assess the equipment, materials, and methods; develop investigation techniques; eliminate negative factors; submit improvement proposals (Nakajima, 1988).
- The one point lesson (OPL) is a training tool that takes from 5 to 10 minutes to enhance the operators' skills (Sun, Yam, and Wai-Keung, 2003).
- Brainstorming is a tool used to help with the difficulty of managing the views of a large group and to run the meeting effectively (Shirose, 1995).
- The why-why analysis or the 5-whys Analysis is a tool which analyse the problem's roots by asking why (Asaka and Ozeki, 1996).
- The single minute exchange of die (SMED), or quick changeover, is a method to reduce downtime caused by any process of change from one product to another. It measures the total time from the moment of completion of the last unit of the first product to the time of commencement of the first unit of second product.
- Spare parts management is one of the key processes which supports effective world class maintenance scheduling and planning and machines reliability improvement (Leflar, 2001).
- Tagging strategy is aimed at eliminating the waste and other ills that we create in the workplaces (Figure 3.6) (Hirano, 1995).
- JIPM refers to activity boards as a guide to action. They present the TPM team with a visual guide to its activities that makes the improvement activities so clear that anyone can immediately understand them (Figure 3.7) (JIPM, 2010).

FIGURE 3.6: The TPM Tagging Cards (LISCO, 2010).

3.11.1 Overall equipment effectiveness (OEE) and TPM six big losses

3.11.1.1 Definitions

The overall effectiveness of the equipment is a comprehensive scale that determines the relative productivity of equipment as compared to the theoretical productivity performance. Moreover, the overall effectiveness of the equipment is used as an indicator of the status of equipment in general, and identification of development needs of the three indicators, namely, availability, performance and quality. The measurement of OEE is combining all the factors that affect the equipment operation including the factors of time, speed, and quality. In addition, OEE is a metric for the assessment of equipment effectiveness and identifying which machine performance is worst and, therefore, indicates where to focus TPM activities (Suzuki, 1994).

Figure 3.8 shows OEE and its calculation. OEE is the traditional and most widely way to measure TPM, and it is reflecting how the equipment performs during the operation and how the overall effectiveness of the equipment is increased which is one of the key elements of TPM. In other words, TPM is about considering the efficiency more comprehensively than the traditional view, and concerning the big losses in the operation as a whole. For instance, in many cases it was found out that about 10% reduction in the direct maintenance costs are equivalent to a 1% improvement in OEE, which comes

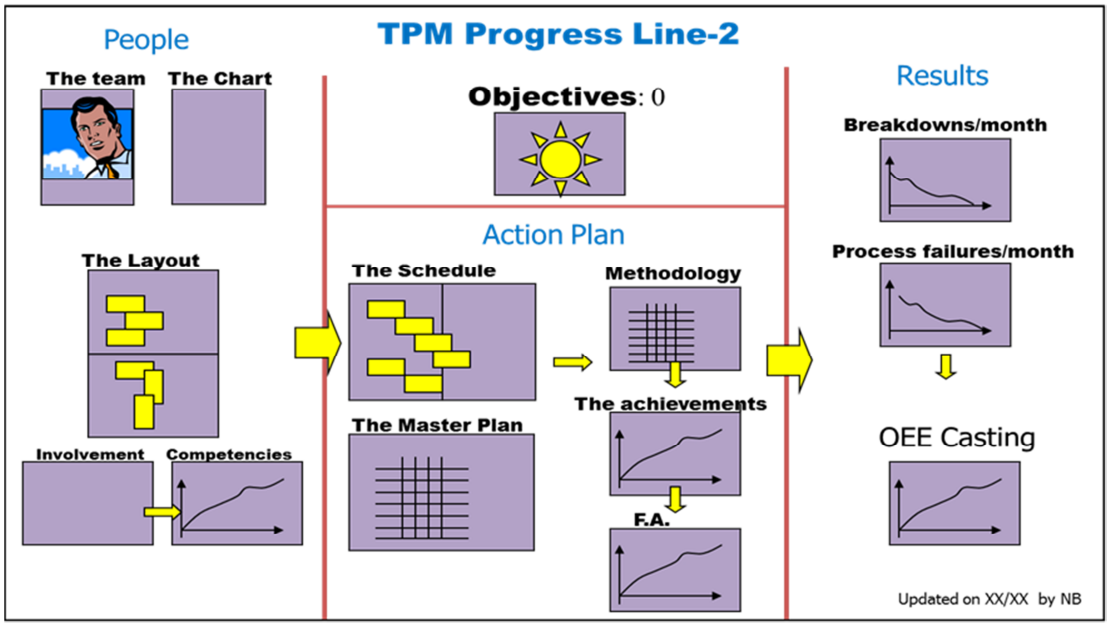

FIGURE 3.7: The Activity Board.

from attacking the hidden losses (Suzuki, 1994). Further, equipment effectiveness is a measure of the value added to production through equipment and TPM maximizes equipment effectiveness through two types of activities: *Quantitative* which is increasing the equipment's total availability and improving its productivity within a given period of operating time, and *Qualitative* which is about reducing the number of defective products stabilizing and improving quality.

3.11.1.2 The Six Big Losses

Downtime losses

- **Equipment failure**: It is the time loss when the equipment breaks down due to some problem. It is often referred to as sudden failure in which the machine stops completely (Nakajima, 1988).
- **Setup and adjustment**: It is the periods in which the equipment was stopped to make some changes to the product or the tools. It may include cleaning and making adjustment to the equipment to get stable quality in the product (Team, 2008).

Speed losses

- **Small stops**: It is the idling and minor stoppages. In other words, it is the events of interrupting the production flow without actually making the equipment fail like a production jam or a warning given to an operator. The losses in this area can be considerable in some cases more than losses caused by breakdown losses (Wireman, 2004).
- **Reduced speed**: They refer to the variance between machine design speed and actual operating speed (Bamber, Sharp, and Motara, 2003). The factors that impact the capacity of the machine are the speed and volume of the output (Wireman, 1991).

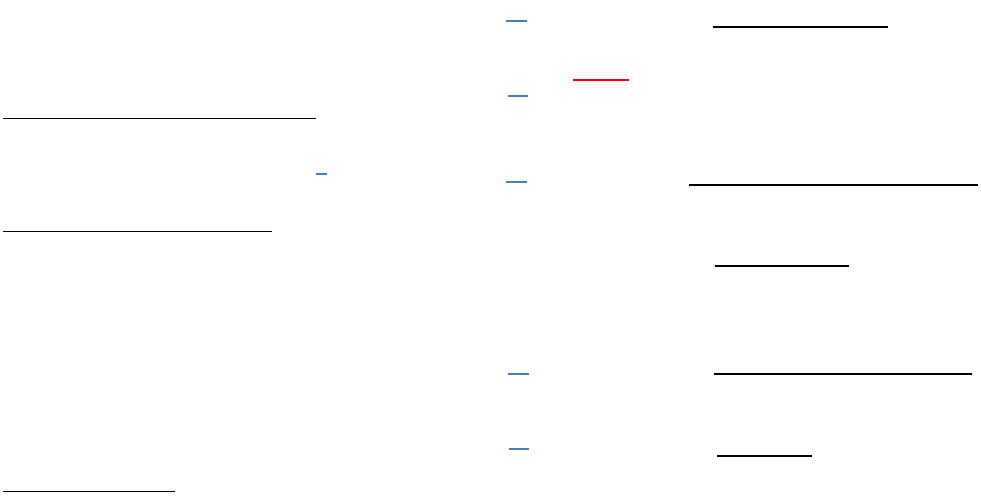

FIGURE 3.8: Overall Equipment Effectiveness Calculation (Nakajima, 1988).

Quality losses

- **Start-up losses**: They are the losses due to low performance in the beginning of the operation of the equipment or the production line till reaching stability (Bamber, Sharp, and Motara, 2003).
- **Production rejects**: They are also known as quality defects and re-work. They are the losses in quality which occur when products are not conforming to the specifications ().

In Table 3.3, the six big losses are shown and how they are related to OEE Loss categories (Vorne, 2008).

3.11.1.3 Other machine losses

The elimination of losses requires not to overlook them no matter how simple are the problems causing them, and to deal with them urgently avoiding to worsen them if delayed and the diagnosis process becomes almost impossible. Therefore, the equipment operators are the primary source of information which would facilitate this task (Leflar, 2001). In most studies the focusing is on the major stops, while the initial activities' basic tasks, such as cleaning, lubrication, adjustment and tie-down, does not get the same attention. However, the minor stops in most automated production lines are responsible for 20 to 30% of the overall effectiveness of the contagious. According to (Nakajima, 1988), the major stops can be avoided if we know the hidden defects and get rid of them. Furthermore, some TPM experts demands to stop the equipment and

TABLE 3.3: Categories of the Six Big Losses (Vorne, 2008)

address the hidden defects and losses before failure occurs where it is the main task of a process of continuous improvement. When applying this step, hundreds of small defects in the equipment will be discovered. Hence, dealing with minor defects leads to the solution of many of the chronic problems that their causes were unidentified (Nakajima, 1988).

3.11.1.4 OEE Factors

Availability It is the actual time for production after subtracting all planned downtime. Further, it is the ratio between the actual time to run the equipment and the planned time for operating the equipment. In other words, it is the proportion of time the equipment is actually available to the time it should be actually operating (Gupta, Tewari, and Sharma, 2006). *Performance* It is the measure of how well the equipment was running when it was operating. It is the actual production rate of the equipment to the theoretical rate taking into account both the minor stoppage and the speed losses (Leflar, 2001). *Quality* It tells us how many good parts versus defective parts the equipment has produced during the time it was running, as well as, the proportion of the good parts to the total parts that have been produced accounting for scrap and yield losses (Leflar, 2001).
In Figure 3.9 the factors of OEE are illustrated.

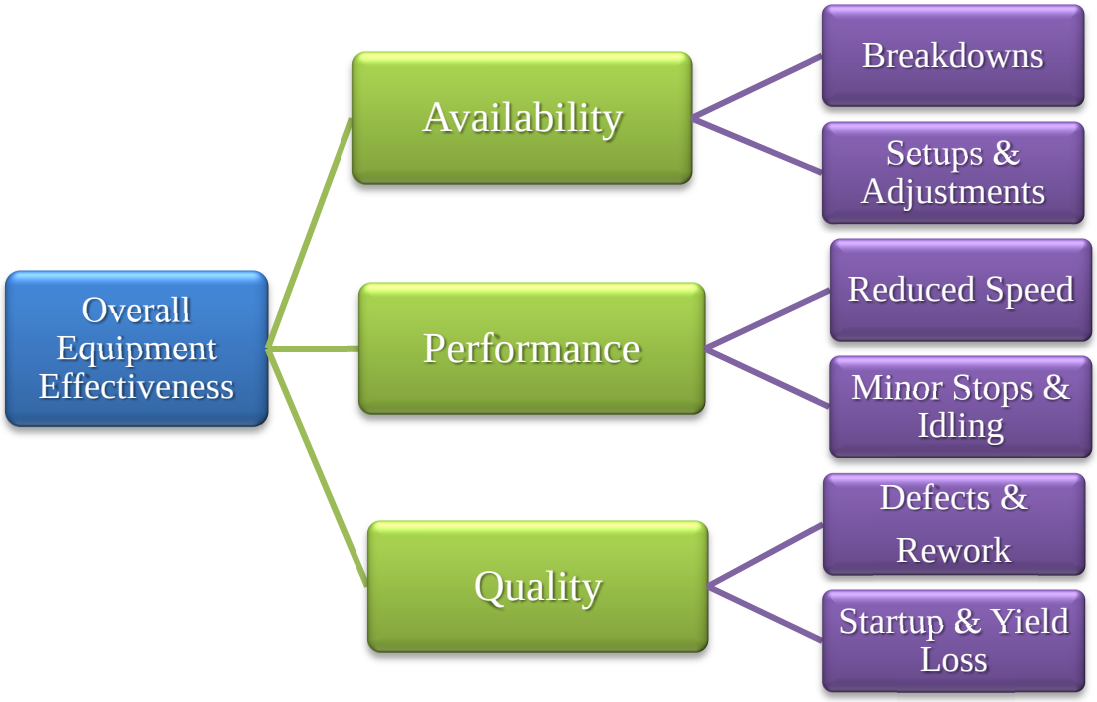

FIGURE 3.9: The OEE Factors.

3.12 Factors affecting successful implementation of TPM

TPM exists in the manufacturing organisations, although the complexity of implementing it may vary dramatically from industry to industry and company to company. In

fact, there is no single right method for implementing TPM. However, TPM implementation depends mainly on some specific factors, for instance, a continuous flow manufacturing facility which is a fully automated facility, would likely get more benefits from implementing TPM system than a manufacturing process composed of simple hand-work operations (Hamacher, 1996). Moreover, the type of industry, service activities, method of production, and equipment conditions differ substantially from firm to firm, and accordingly, these factors must be taken into account when implementing TPM. Furthermore, skill and age of the employee, complexity and age of the equipment, the culture of the organisation and the existing maintenance program are very important factors as well (Wireman, 2004).

In the same context, Nadarajah, Sambasivan, and Yahya (2005) cited that implementing TPM must consider the plant configuration, the local history and the the culture at the organization (Nadarajah, Sambasivan, and Yahya, 2005). Hence, each company intends to maximize the equipment effectiveness by using TPM must determine its own action plan individually to meet its needs and to suit its individual requirements (Nakajima, 1988). One of the most important features of the TPM program is that there is no need to implement the whole program once, it is possible to adapt the TPM program according to the culture of your organization and can choose the elements of the program that fit the circumstances of your organization. Similarly, Wireman (2004) has mentioned that the difficulty of implementing TPM is not because it was technically hard to get the result, but because the resistance from the participants to change the culture of the organization (Wireman, 2004). The TPM program requires changing the culture of the organization in terms of out look to the responsibility and its functions, furthermore, the participants must give necessary sense of commitment and ownership. T.Albert and P (2000) said that companies that are ready to change their culture will implement TPM successfully (T.Albert and P, 2000). Therefore, managers must turn attention to motivation, involvement and acceptance to the readiness to change. As a consequence, it is not surprisingly, at the beginning, that the program will face resistance from the employees, especially the less educated ones, so a climate of confidence and synergy must be created and also developing effective channels of communication with all participants is highly needed.

Certainly, driving any improvement process by the top management of the organization would encourage the employees and gives the coordinators credibility. Thus, in many cases the top management of the company is responsible for the TPM success or failure (Rodrigues and Hatakeyama, 2006). Employees, in turn, must have been convinced that the top management is committed to this program in order to implement TPM ideas.

The Implementation of TPM faces many challenges in both public and private sectors due to several reasons such as the bureaucratic and top down management style (Seth and Tripathi, 2006). On the other hand, Nakajima pointed that companies that are already applying productive maintenance, adopting TPM would be very easy by supplementing autonomous maintenance by small group activities, but for companies who have not yet implemented productive or preventive maintenance, sudden turn to TPM will not be easy, However, in the same time it is not impossible (Nakajima, 1988). Furthermore, Wang and Lee (2001) cited that companies who focused to improve their quality must also enhance their maintenance system and the equipment efficiency. Whereas (Nakajima, 1988) believes that supporting TPM logistically with

an efficient flow of resources and information is absolutely necessary to an efficient production achievement. Accordingly, the success of maintenance as a part of TPM depends mainly on the availability of the right information which is as important as the technical and engineering skills.

All TPM experts agree that TPM implementation takes from 3 to 5 years from introducing TPM to achieving the prize-winning results (Wang and Lee, 2001).

The factors affecting the TPM implementation may be summarised as follows:

1. ***Management Commitment*** **(MC)**
   The commitment of senior management is a prerequisite for the successful implementation of TPM. The commitment is a broad concept that includes physical and moral forms of support as well as participation. The top management support is required through the development of the vision and policy related to TPM, in addition to the provision and adoption of the financial allocations for the application and providing advisory services, and also, linking the system of rewards and wages in a manner consistent with the application of TPM. This is in addition to attending regular meetings of the TPM committees and the adoption of ideas and proposals for improvement projects.

   According to (Steinbacher and Steinbacher, 1993), the senior management cannot give lip service to TPM and expect it to succeed, but instead the commitment must be wholehearted and unwavering. Therefore, strong commitment and unwavering support to TPM is necessary for establishing the favourable environment at the preparation stage of the implementation. It is also needed in planning and coordinating for its implementation (Nakajima, 1988). Consequently, commitment of the participants to the program is the key factor in any successful TPM implementation. Furthermore, Hansson, Backlund, and Lycke (2003) stated that the commitment of the management is clearly a key factor which must be present before launching a TPM implementation process as long as the management is responsible for the availability of resources and the overall implementation approach (Hansson, Backlund, and Lycke, 2003). Similarly, A. S. Piechnicki and Herrero (2015) believed that top management commitment is among the key factors of TPM implementation.

   According to the above, in order to ensure excellence and success in implementation of TPM, companies that adopt such strategies must provide support, understanding and commitment to this strategy as well as training and motivation of the various levels of the organization.

2. ***Employee involvement*** **(EI)**
   Total involvement of the plant employees is considered crucial to the TPM success. It generates pride and job satisfaction as well as financial benefits (Robinson and Ginder, 1995). Employees actually execute the activities during the implementation and they play a main role. Hence, the successful implementation requires the participation of every person that has an effect either directly or indirectly on the effectiveness of equipment and every person should know the value and importance of performance and reliability of the equipment and their role in this area. Through the experience in the application of TPM at Tennessee Eastman Company, Maggard, Bailey, and Moss (1989) mentioned that the importance

of keeping people involved with the change is a vital element of success and a good implementation plan is the one that relies heavily on the element of participation.

Therefore, from senior management in the operation and maintenance department down to the operators and mechanics, a great conscious efforts should be made to participate everyone at all levels of the company (A. S. Piechnicki and Herrero, 2015). This can be achieved through the construction of interlocking and cooperating teams to support the installation process. Further, each team has a specific role in the plan and a special responsibility lies on it, that is, from deciding where to start the implementation to identify the team members and so forth, until the determination of the actual tasks and functions of TPM. However, the interlocking (overlapping) of these teams gives the necessary communications link between these trends and help in building ownership concept. However, the expert Maggard mentioned that the involvement of everyone, especially in the early stages, is not always possible, so it is better to use team representatives from the groups which will be involved and these individuals will become the ears, eyes, and voices for everyone else. They are encouraged to keep their groups apprised of progress and to provide feedback from the work group to the team which is planning TPM application in their area Maggard, Bailey, and Moss (1989).

The lack of commitment and involvement from affected personnel is one of the difficulties are encountered during TPM implementation (Arca and Prado, 2008).

3. ***Motivation, Rewards and Recognition*** **(MRR)**
   There is no institutionalized system that is most powerful than the system of bonuses and wages. In fact, the acts that are rewarded and appreciated will attract individuals to carry out working with high morality and in a challenging environment. Therefore, senior management must strongly supports a full review of the system of bonuses and wages to ensure that it directs behaviour and performance in the right direction. These amendments must be on the basis that fits and supports the success of the application of TPM, for example, the distribution of revenues and profits for workers would lead to motivate workers to increase productivity and reduce the losses which are the main tasks of TPM. P. S. Poduval and Raj (2015) mentioned that top managers should be able to retain staff through providing wages and employee benefits and facilities on a par with the world standards.

   The most powerful reward in the workplace is the management's positive attention to people doing the work. However, people have different ideas about rewards and punishments, so managers would do well to understand what can meet their needs (Leflar, 2001). Further, motivation is the key to small group success and improves the skills of he members and gives them opportunity to discover themselves (Suzuki, 1994). In the same way, giving the employees who are involved in doing TPM tasks a symbolic tangible and social reward to reinforce them is the main thrust of management performance (Bill and Maggard, 1992).

4. ***Time allocation for implementation*** **(TA)**

The investment of time for the application of total productive maintenance is essential to the success of the program. There is a need for sufficient time for training and transfer of expertise and skills to the operators to become maintenance workers. Moreover, to allocate the necessary time to train teams for improvement and allow them to hold regular meetings. This is in addition to the time for the work of cleaning, oiling, and lubrication, which should be a daily routine work. However, expecting quick results, could lead to the failure of the program due to the fact that TPM programs require some investments in time and efforts at the beginning in order to dispose dust, rust and all other forms of dirt as well as returning the equipment to their good condition, then the results of these investments gradually appear thereafter in the form of reducing waste, increasing productivity and quality improvement.

The insufficient time allocation for implementation, the lack of serious management and the lack of support are the most basic forms of the reasons of programs failure (McCarthy and Rich, 2004). In this context, Nakajima (1988) stated that achieving satisfactory results of the application of TPM programs does not come overnight, but takes an average of three years starting from the introduction of the program until the final results and the award. Hence, it is worth saying that the time required for the application depends on the size of the company involved in the program, the level of technology used, the management standards and the current level of maintenance. Nakajima added that many top managers who are enterprising and eager to implement beneficial programs may say that if other companies can do it in three years, we can do it in one. It seems that their enthusiasm is commendable, but to invest so little time in the undertaking of this scope can only lead to failure (Nakajima, 1988).

Accordingly, allowing sufficient time is needed for the successful TPM implementation, otherwise failure is expected.

5. ***Resource allocation for implementation*** **(RA)**
   The successful application of TPM tasks requires extensive resources for their accomplishment. The resources here means all that can be needed in all stages of the application starting from the stationery tools, means of illustration and presentation used in training, meeting rooms, spare parts and tools and equipment. This is in addition to some other materials such as painting, grease, oils, etc. Therefore, The top management should not stop at the development and adoption of a special budget for TPM program and should provide the resources required for the success of the application, and should prefer to work to deliver the news and procedures for each individual in the company that explains clearly what is meant by this program, because the lack of sufficient resources will certainly reduce the chances of success of the program and it will be a major inhibitor to effective changes (McCarthy and Rich, 2004).

6. ***Alignment to company mission*** **(ACM)**
   Each company needs to set on a company-wide policy to guide the daily work and should set a vision to move to the future through its commitment to a set of principles and values. Developing a policy and a vision for TPM program that aligns with the overall policy and vision of the organization is the responsibility of the top management. Moreover, exerting efforts and spending time by senior management to develop this TPM policy and vision gives an indication of

a strong and positive signal and commitment of senior management to the TPM program. Therefore, before starting the implementation of the TPM or any other maintenance program, a thorough study must be done to take into account the compliance with the company's mission and plans (Park and Han, 2001).

In general, the establishment of the basic goals and policies for TPM is more difficult than it is expected. The competent committee to develop these policies and goals must have the full approval and approbation of management. In addition, TPM policies and goals are an integral part of the company mission, vision, and guide principles, so these policies and goals should address the needs of employees, customers and stockholders (Robinson and Ginder, 1995).

When establishing TPM goals and policies they must link with the company's business goals and targets that are necessary in order to achieve TPM implementation, and they must be aligned with company policy in mid/long term business plan (Chan et al., 2005). Furthermore, Nakajima pointed out that the basic TPM policies and goals should be established by TPM office staff since it requires about three years to work on eliminating defects and breakdowns through the TPM program, on the other hand, basic management policies and goals should support and commit to the TPM program. Although policies may contain verbal or brief written statements, the goals should be accurate and quantifiable and should determine what is the target, how much, and when it will be gained (Nakajima, 1988).

7. ***Performance measurement*** **(PM)**
TPM results are highly measurable as it focuses on the elimination of the losses and the main causes of the equipment's low performance, so it is a database of equipment and development strategies and hence performing any other work that does not enter within the scope of the TPM program is just beautifying the equipment. Practicing "profitable TPM" and pursuing optimal equipment efficiency requires following two crucial factors. First, keep precise equipment operation records, which give the opportunity to provide appropriate management and control within narrower targets. Second, creating an accurate scale that can measure the equipment operation conditions. The calculation of OEE must include all six of the big losses of equipment so that it combines the elements of time, speed, and quality of the operation of the equipment and measures how these elements can increase TPM added value (Nakajima, 1988). Moreover, benchmarking your first measurement before the implementation and late measurement after the implementation of TPM is very important, because it makes you able to see your improvement opportunities (Hartmann, 1992). Similarly, Rodrigues and Hatakeyama (2006) stated that the success of TPM implementation is closely linked to the management of people and it is necessary to develop key indicators for the assessment of performance of the program. These key performance indicators are used to validate the progress of the TPM activities and are productivity, quality, cost, safety, and morale issues (Rodrigues and Hatakeyama, 2006).

The initial measurement of OEE can determine the current equipment performance levels which facilitates the setting priorities of improvement (Willmott and McCarthy, 2001).

8. ***Implementation plan and process*** **(IP)**
   As mentioned previously, the most important feature of TPM program is that there is no need to implement the whole program at once, but rather, it is possible to adapt the total productive maintenance program in accordance with the organization's culture (in terms of values and standards), Where the components of the program are selected according to the compatibility with the current circumstances of the organization. Correspondingly, each company that intends to maximize equipment effectiveness by using TPM must determine its own action plan individually to meet its needs and to suit its individual requirements (Nakajima, 1988). Here, it should be noted that there are differences in some practical details and procedures, but the main steps of the implementation in most companies that have succeeded in TPM used the Japanese Institute 12-step model. For this reason, Leflar (2001) mentioned that it is a waste of time and other resources to try to re-invent TPM, but rather, it is important to learn from others who have succeeded at creating a factory with a world-class productivity (Leflar, 2001) (A. S. Piechnicki and Herrero, 2015).

   The TPM program is like a heart transplant, if it does not match with the patient, it will be rejected. Therefore, each company must be treated as a unique case and adapt the TPM principles to fit the local factory's specific issues without spoiling the well-established and proven principles of TPM (Willmott and McCarthy, 2001). In general, total productive maintenance is like any other system, it requires a master plan to identify the implementation steps and the expected time for the implementation. The master plan is the responsibility of the TPM Office. The TPM master plan must include the daily schedule beginning with preparation phase to the phase of the implementation and stabilization (Nakajima, 1988). The establishment of a master plan for TPM implementation is one of the challenges of the preparation phase of TPM implementation, which needs an enormous amount of data and analysis by the TPM committees staff and due to the criticality of this step, many institutions use some expertise from outside (Robinson and Ginder, 1995).

9. ***Effective Communication*** **(EC)**
   The act of communication is the way people understand each other and the way of transferring information in the organizations (including policies, prospects, emotions, rumours, failure, and other human experiences) (Denise, 1999). The effective communication is essential for all stages of the change processes, it is needed for clarifying and determining the future of the situation in terms that are relevant and concrete to the involved people in the organization at all levels. Many employees, especially in the maintenance departments, believe that TPM threats their job security thinking that when transferring their skills to the operators and reducing equipment waste will lead to the labour redundancy, and by the same token, some operators believe that TPM increases the workload without any increase in their income. From here, TPM committees should clarify and correct some misconceptions through communicating the real notions and goals of TPM.

   The Communication operation and raising awareness of the need for TPM must be done at every level in the organization. Furthermore, a good communication will bring to the program a very clear understanding at every turn (Steinbacher

and Steinbacher, 1993). For this reason, in the preparation phase of TPM implementation, the communication must be in the level required to avoid the occurrence of resistance to the program by any participant (Willmott and McCarthy, 2001). By all means, effective communication creates a strong relationship between the involved personnel and will motivate the involved people. Hence, utilizing good communication and management skills will keep the employee input at high level (Wireman, 2004).

10. ***Integration with other manufacturing management programs*** **(IMM)**
Ensuring the success of manufacturing improvement strategies cannot occur without the integration of these systems and strategies with each other. For example, you cannot reduce inventory without reducing the percentage of defective products and you can not apply the pull production system without reducing the production time of adjusting the equipment and equipment failures. Similarly, the Just-in-Time program will not work unless you have highly reliable and effective equipment where the interface between people and machine is maximized and in fact this is a major objective of TPM (Willmott and McCarthy, 2001).

    In fact, there are many studies on TPM implementation proposes that integrates TPM with other manufacturing strategies for improving performance, which ultimately leads to competitiveness. In effect, these approaches and strategies with each other are constantly seeking to solve the existing problems in the shop floor, besides, appropriate selection and careful integration of the components of a hybrid system provides the strengths of each approach used (Park and Han, 2001). Thereupon, TPM has fairly gained attention as primary methodology for improvement and its activities are suitable and consistent with many of other improvement philosophies. For instance, total productive maintenance integrates with total quality management activities, because both strategies relies on participants and empowerment (Willmott and McCarthy, 2001).

    Henceforth, TPM is the foundation for all other manufacturing programs. In other words, without TPM, the TQM and JIT would have not existed and the integration of long-term maintenance functions with other manufacturing programs functions in the organization, can provide many advantages such as saving money and time as well as other useful resources (Ahuja and Khamba, 2008c).

11. ***Cooperation*** **(CN)**
Cooperation denotes the collective efforts by people working in the organization for mutual benefit and often it becomes a call for increased socialization to a culture, not a prompt for high performance (Denise, 1999). In fact, TPM is an influential force in the performance of the organization that strengthens its competitive position. Consequently, in order for TPM to success, it is supposed to be supported from everyone by encouraging the creative process within the organization and inspiring the spirit of cooperation and creativity among employees.

    The implementation of TPM represents the approach of completing the work that the organization is accomplishing by maximizing the competitiveness through continuous improvement of the quality, productivity, personnel moral, and the environment and through the window of cooperation between management and workers and the adoption of teamwork. For this reason, when there is a lack of confidence and the strained relationship between supervisors and employees,

more efforts should be made to ensure the success of TPM implementation. Moreover, the well introduction of TPM system will boost the organizations to improve this relationship (Maggard, 1992a).

The readiness of cooperation within the organization is one of the important issues when implementing TPM (Park and Han, 2001). Henceforth, TPM program stresses that employees, operators, maintenance personnel, and engineers, must work as a team to maximize the overall equipment effectiveness through actively seek innovative solutions to eliminate waste of equipment problems. In particular, it requires that this disparate group of people should work cooperatively, even though, they have different concerns (Park and Han, 2001).

Thereupon, the success of the implementation of TPM system depends on the cooperation of all the organisation's departments. That is, maintenance and operations, including technicians and engineers as well as designers and planners should be involved in the program. Nakajima went further by stating that in order to ensure the successful implementation of TPM program, organisations need cooperation and consultation with managers of companies that have implemented TPM program successfully in the past (Nakajima, 1988).

12. ***Coordination and leadership*** **(CL)**
Coordination is the act of harmonious functioning making different people work together for the purpose or effect to achieve the desired goals of the organization (Denise, 1999). The Work that is being coordinated involves more than one person, includes common goals, requires clear understanding of the roles and responsibilities, and, in general, is supervised by someone called the coordinator. The work of the coordinator is the link between the parties involved in the program, including consultants from outside the organization. Of course, TPM participants need knowledgeable guidance from their leaders as the employees won't change their way of work because this is the desire of some TPM consultant who came from outside the company or other TPM managers. In fact, they only change when their managers want them to do so and support the changed behaviour rightly (Leflar, 2001).

    The most important people to the successful implementation of TPM are the firm's CEO's, president, and vice president. It is worthmensioning that the importance of leaders for the successful implementation of TPM is like the importance of generals for their soldiers in the battle field (Leflar, 2001). Therefore, TPM system should be coordinated in the organization by someone who is enthusiast of this system and who is assigned on the basis of a full-time, at least during the preparation and implementation stages (Park and Han, 2001).

13. ***Culture and receptivity to change*** **(CC)**
At the present time, various organizations are dealing with dynamic environmental conditions that change rapidly. In this changing environment, the people who are involved must adopt strategies that allow to confront these environmental threats and maintain their competitive position. Thus, it is necessary to deal probably with the concept of resistance to change by a number of non-supporters of change who might spend a series of efforts trying to refrain the change and not to succumb to the change of implementing the new process, procedure or particular behaviour and the desire to maintain the status quo and stay on what it

is in the current reality. Consequently, convincing everyone in the company for the need of change is one of the difficulties facing the implementation of TPM (Steinbacher and Steinbacher, 1993).

The successful implementation of TPM requires sensitivity to the underlying culture which controls the way of accomplishing tasks within the organization. A. S. Piechnicki and Herrero (2015) referring to A study carried out in large- and medium-sized organizations by Aspinwall and Elgharib (2013) shows that culture change has been the main obstacle for implementing TPM. Moreover, it is important to pay good attention to some basic details about the people involved in the organization and their methods of administrative and vulnerability to change because that could affect the success of the implementation of the program. Equally important, the change related to the TPM program may affect the daily work routine of the employees, and as a consequence it might converts the content of the work and hence may be seen as a threat to wages, safety and job security. In the light of the above, TPM in the overall is a culture change shifting workers from being careless about activities not related to their specialization, into workers who are ready to help and participate in all kinds of useful works (Maggard, Bailey, and Moss, 1989).

Definitely, the TPM is not a project, but it is a change process introduced to companies and must be firmed up to become an integral part of the daily routine work of all employees. Further, receptivity to change is crucial for TPM implementation where participants differ in terms of level of education and their enthusiasm for learning (Chan et al., 2005).

14. ***Availability of information and documentation*** **(AID)**
The success of maintenance as a part of TPM depends on the availability of the right information, which is as important as the technical and engineering skills. Documentation and information management play an important role in the effective management of developed projects (Willmott, 1994b). Moreover, Wireman (2004) pointed out that the CMMS, also known at times as an Equipment Management Information System (EMIS), is a computerized version of a manual system and it is a tool to be used in the journey of continuous improvement and the main goal behind it is to enhance the maintenance management and the organization's assets. Furthermore, the timely and accurate data that is collected by the CMMS and the use of data by the organization determines the success or failure of the improvement initiative.

   The documentation of data and keeping a record of equipment and make it accessible to everyone helps solving future problems, therefore, Ljungberg suggested to use a way to record data on computerised systems combined with manual recording in order to give an accurate assessment and deeper understanding of the reasons for the losses (Ljungberg, 1998). Also, the computerized technology allows employees to routinely monitor and check the calibration of equipment which is a very important issue in the manfacturing industry (Maggard, 1992a).

15. ***Empowerment*** **(ET)**
TPM is an empowerment process for giving ownership and shared responsibilities and this is considered as one of the factors that was recognized and applied by the companies that succeeded in TPM implementation (Willmott, 1994b). In

order to ensure the success of TPM, the implementation teams should have an independency to determine their tasks without the intervention of management (Maggard, Bailey, and Moss, 1989). Thus, taking a more active role in decision-making and accept responsibilities in the organization and its assets, is part of the requirements of employees in TPM programs. However, Sometimes the misconception of the meaning of employee empowerment, which means that all decisions must be placed by the workers and small group activities, can lead to chaos in the work. Therefore, regulations and rules are very important to avoid confusion and chaos caused by freedom of taking decisions by workers. In addition, the most difficult aspects of empowerment are identifying which decision should be taken by management, workers, or by combination of both. Similarly, many organizations make a wrong judgement in not giving enough authority to workers (Robinson and Ginder, 1995).

In summary, workers must be given empowerment to the extent that they are willing to accept responsibility for their actions because empowerment process blurs the traditional boundaries between functions and levels.

16. ***Formation of TPM office and steering committees*** **(FSC)**
Organizational matrix and horizontal groups, such as project teams and committees, at every level of the organization is critical and extremely important for successful development of TPM company-wide (Nakajima, 1988). In other words, when the initial educational stage has been concluded, a TPM deployment committee can be prepared to study and review basic implementation methodologies and strategies. These steering committees' members are to communicate information and to cooperatively make decisions (Robinson and Ginder, 1995).

    The importance of setting up these committees is that they will conduct progress review of the process in each plant area to communicate and co-ordinate. Moreover, selecting the team members is very critical to the success of the implementation process (Narender and Gupta, 2012).

17. ***Existing maintenance system, equipment and workplace conditions*** **(EMS)**
The good fundamental maintenance program will ensure success in TPM implementation (Robinson and Ginder, 1995). Further, keeping the equipment available at all times in good condition is very costly, but, on the other hand, allowing it to run in the presence of many defects is more expensive. Therefore, eliminating the six big losses to improve equipment effectiveness is one of the requirements to implement TPM successfully (Nakajima, 1988). Likewise, (Wireman, 2004) referred that many problems in implementing TPM successfully are due to factors such as complexity of the equipment and age of the equipment, as well as the current status of the maintenance program.

    In order to fully implement world class programs, industry must underpin their efforts toward competitiveness with a solid foundation of maintenance basics and a clear management commitment to effective machine maintenance and asset management. Hence, restoring the equipment to its first good conditions is a critical first step in focused improvement process, which is known as one of the TPM pillars. In like manner, maintaining basic equipment conditions is a maintenance practice that is ignored in most companies today, so when the maintenance group gets occupied with capacity loss breakdowns and trying to keep the equipment

running properly, basic tasks like cleaning, lubricating, adjusting, and tightening are neglected.

18. ***Training and education*** **(TE)**
Education and Training aims to provide operators with different skills so that they can accomplish all the tasks required of them very effectively and independently. However, sometimes the operators do not understand principles of operating the equipment and the maintenance personnel may not know some modern maintenance methods, therefore, training must be included as a basic requirement for TPM to improve the skills of all employees. Training might include: training on autonomous maintenance , training on the proper operation of the equipment, training on methods such as, root cause analysis to find out the causes of problems. (Nakajima, 1988).

    Training Increases the skills of maintenance personnel and operators and it should be conducted from the beginning of TPM campaign by giving hours of awareness, visiting some success TPM plants, and one-point lessons. The one-point lessons is part of the operator training documentation that can also be given as an attachment to machine operating or maintenance specifications.

    Training and Education TPM participants may be the most critical of all TPM factors for keeping the TPM program running in the long-term. In fact, a test of TPM success is to look at the organizational learning (Leflar, 2001). Moreover, a well-developed training system is one of the key factors for implementing TPM that needs to be updated as often as the rapid change of technology (A. S. Piechnicki and Herrero, 2015).

19. ***Union participation and acceptance*** **(UPA)**
Many organisations selecting TPM program are leaders in the market share, quality life, and financial stability. In effect, this stability has great impact on job security, and is linked to effective communication between management and first floor workers, including union leaders. However, if union leaders recognize TPM's capability to positively affect the plant, they will join effectively in the improvement process. Hence, understanding TPM and allowing unions and workers to access the strategic decision making processes can help guarantee the success of TPM implementation (Robinson and Ginder, 1995).

    The popular expressions that says "if they are not with you, they are against you" is indeed applicable, so the union leaders and members should be involved in TPM implementation in the early phase. Once the union leaders and members see the TPM advantages and how it is influential in improving employee skills and job security and once they understand how TPM improves the quality and safety of work life and recognize that they are indeed partners in the process, they will support the program strongly and effectively (Stephens, 2010). Moreover, the participation and acceptance of the union is a very important issue to minimize TPM challenges, even though you their enthusiastic support is not needed. Therefore, cooperation between unions, management, and workers is crucial to the successful implementation of TPM in large companies.

20. ***Pilot project and gradual implementation on model machines*** **(PPGI)**
Total productive maintenance is designed to deal with the problems and raise

performance, especially in the places that represent a bottleneck in the productivity and the real success is to solve these problems. The gradual application of the TPM activities eases and helps taking advantage of some mistakes facing the implementation process. Henceforth, it is preferable not to apply TPM to all equipment and locations at once, but rather, some sites and the equipment must be selected to be a mode for TPM implementation. the pilot project starts with the selection of TPM team members and the model machines. However, there are three key criteria for the selection which are the machines are process bottleneck, uniqueness of the machine, and low availability (Sun, Yam, and Wai-Keung, 2003). This method makes the workers see the benefits of TPM program on these sites and equipment, thus are more convinced. In fact, emphasizing on pilot project and gradual implementation of TPM on a handful of machines at given time made Rover succeeded in using TPM (Bohoris et al., 1995).

Finally, a well planned TPM pilot study will help to define the priorities and required tasks where the implementation must be developed based on the result of the pilot study.

3.12.1 Critical analysis of the literature review

TPM has striven to enhance the OEE and to alleviate production losses through continuous improvement of organizational systems and maintaining the assets. Accordingly, an attempt was done to survey the literature on the important factors in the process of TPM implementation. Further, an extensive review of literature on TPM was established for the purpose of clarifying and identifying critical factors that are fundamental for TPM implementation. In fact, through the extensive and deep literature review, many success factors of TPM implementation were identified based on reviews of various models, and conceptual frameworks of academics, consultants, practitioners along with empirical studies. In addition, several factors which affect the successful implementation of TPM were identified. Table 3.4 shows a comprehensive list of the key factors and literature support.

No	Factor	Key authors
1	Management Commitment	(Nakajima, 1988);(Maggard, Bailey, and Moss, 1989) (Steinbacher and Steinbacher, 1993);(Suzuki T. , 1994) (Willmott P.,1994a);(Robinson and Ginder, 1995) (Davis R.,1997);(Fredendall and Patterson,1997) (Bamber, Sharp, and Hides, 1999);(Cooke, 2000) (Hartmann E., 2000);(Ireland and Dale, 2001);(Leflar, 2001) (Park and Han, 2001);(Willmott, Peter; McCarthy, Dennis, 2001) (Mora, 2002);(McCarthy and Rich, 2004) (Srivastava and Srivastava, 2004); (Wireman,2004) (Chan, Laub, Ip, Chan, and Kong, 2005);(Ahuja and Khamba, 2008a)
2	Employee Involvement	(Nakajima, 1988);(Maggard B. N., 1992a); (Tajiri and Gotoh, 1992); (Suzuki T., 1992);(Steinbacher and Steinbacher, 1993);(Willmott P., 1994a); (Robinson and Ginder, 1995); (Davis R., 1997);(Fredendall, Patterson, Kennedy, and Griffin, 1997);(Bamber, Sharp, and Hides, 1999); (Ben-Daya, 2000); (Cooke, 2000); (Hartmann E., 2000); (Leflar, 2001); (Park and Han, 2001); (Ferrari, Pareschi, Regattieri, and Persona, 2002);(Mora, 2002);(McCarthy and Rich, 2004);(Srivastava and Srivastava, 2004);(Wireman, 2004); (Chan, Laub, Ip, Chan, and Kong, 2005); (Kelly, 2006);(Ahuja and Khamba, 2008a)
3	Motivation, Rewards and Recognition	(Nakajima, 1988); (Hartmann E. H., 1992);(Maggard, Bailey, and Moss, 1989) ;(Tajiri and Gotoh, 1992); (Steinbacher and Steinbacher, 1993); (Robinson and Ginder, 1995); (Bamber, Sharp, and Hides, 1999); (Leflar, 2001); (McCarthy and Rich, 2004); (Srivastava and Srivastava, 2004); (Ahuja and Khamba, 2008a)
4	Time Allocation for Implementation	(Nakajima, 1988); (Hartmann E. H., 1992); (Suzuki T. , 1994); (Robinson and Ginder, 1995); (Davis R. , 1997)(Bamber, Sharp, and Hides, 1999); (Wang and Lee, 2001)(Willmott, Peter; McCarthy, Dennis, 2001); (Hansson, Backlund, and Lycke, 2003)(McCarthy and Rich, 2004); (Srivastava and Srivastava, 2004);(Chan, Laub, Ip, Chan, and Kong, 2005); (Kelly, 2006)(Ahuja and Khamba, 2007)

5	Resource Allocation for Implementation	(Nakajima, 1988);(Maggard, Bailey, and Moss, 1989) ;(Willmott P. , 1994a); (Davis R. , 1997);(Cooke, 2000); (Hansson, Backlund, and Lycke, 2003); (McCarthy and Rich, 2004); (Chan, Laub, Ip, Chan, and Kong, 2005); (Kelly, 2006); (Ahuja and Khamba, 2007)
6	Alignment to Company Mission	(Nakajima, 1988);(Maggard, Bailey, and Moss, 1989) ;(Suzuki T. , 1994); (Robinson and Ginder, 1995); (Bamber, Sharp, and Hides, 1999); (Cooke, 2000); (Srivastava and Srivastava, 2004); (Chan, Laub, Ip, Chan, and Kong, 2005); (Ahuja, I.P.S; Khamba, J.S, 2008b); (Ahuja, I.P.S.; Khamba, J.S., 2008c)
7	Performance Measurement	(Nakajima, 1988); (Hartmann E. H., 1992); (Maggard B. N., 1992a); (Steinbacher and Steinbacher, 1993); (Willmott P. , 1994a); (Leblanc, 1995); (Robinson and Ginder, 1995); (Al-Najjar, 1996); (Davis R. , 1997)(Bamber, Sharp, and Hides, 1999); (Prickett, 1999); (Leflar, 2001); (McCarthy and Rich, 2004); (Srivastava and Srivastava, 2004); (Chan, Laub, Ip, Chan, and Kong, 2005); (Ahuja and Khamba, 2008a)
8	Implementation Plan and Process	(Nakajima, 1988);(Maggard, Bailey, and Moss, 1989); (Suzuki T. , 1994); (Robinson and Ginder, 1995); (Davis R. , 1997); (Fredendall, Patterson, Kennedy, and Griffin, 1997); (Bamber, Sharp, and Hides, 1999)(Cooke, 2000); (Leflar, 2001); (Park and Han, 2001); (Srivastava and Srivastava, 2004); (Ahuja and Khamba, 2008a)
9	Communication	(Nakajima, 1988); (Steinbacher and Steinbacher, 1993); (Willmott P. , 1994a); (Robinson and Ginder, 1995); (Davis R. , 1997); (Fredendall, Patterson, Kennedy, and Griffin, 1997); (Cooke, 2000); (Tsang and Chan, 2000); (Park and Han, 2001); (Mora, 2002); (McCarthy and Rich, 2004); (Srivastava and Srivastava, 2004); (Wireman, 2004); (Chan, Laub, Ip, Chan, and Kong, 2005); (Kelly, 2006); (Ahuja, I.P.S.; Khamba, J.S., 2008c)
10	Integration with Other Manufacturing Management Programs	(Nakajima, 1988); (Steinbacher and Steinbacher, 1993); (Jostes and Helms, 1994); (Willmott P. , 1994b); (Robinson and Ginder, 1995); (Fredendall, Patterson, Kennedy, and Griffin, 1997); (Park and Han, 2001); (Willmott, Peter; McCarthy, Dennis, 2001); (McCarthy and Rich, 2004); (Ahuja, I.P.S.; Khamba, J.S., 2008c)
11	Cooperation	(Nakajima, 1988); (Steinbacher and Steinbacher, 1993); (Willmott P. , 1994a); (Bohoris, Vamvalis, Tracey, and Ignatiadou, 1995); (Cooke, 2000); (Park and Han, 2001); (Srivastava and Srivastava, 2004); (Wireman, 2004); (Kelly, 2006)
12	Coordination and Leadership	(Maggard, Bailey, and Moss, 1989) ; (Steinbacher and Steinbacher, 1993); (Suzuki T. , 1994); (Fredendall, Patterson, Kennedy, and Griffin, 1997); (Leflar, 2001); (Park and Han, 2001); ; (McBRIDE, 2004); (Gupta, Tewari, and Sharma, 2006); (Ahuja, I.P.S.; Khamba, J.S., 2008c)
13	Cultural Change, Knowledge, Beliefs and Acceptance	(Hartmann E. H., 1992); (Maggard B. N., 1992a); (Robinson and Ginder, 1995); (Bamber, Sharp, and Hides, 1999); (Lawrence, 1999); (Leflar, 2001); (Park and Han, 2001); (Mora, 2002); (McCarthy and Rich, 2004); (Srivastava and Srivastava, 2004); (Wireman, 2004); (Ahuja and Khamba, 2007); (Ahuja, I.P.S.; Khamba, J.S., 2008c)
14	Computerized Maintenance Management (CMMS) and Documentation	(Maggard B. N., 1992a); (Tajiri and Gotoh, 1992); (Willmott P. , 1994a); (Bohoris, Vamvalis, Tracey, and Ignatiadou, 1995); (Robinson and Ginder, 1995); (Leflar, 2001); (McBRIDE, 2004); (McCarthy and Rich, 2004); (Wireman, 2004); (Ahuja and Khamba, 2008a)
15	Empowerment	(Maggard B. N., 1992a); (Steinbacher and Steinbacher, 1993); (Robinson and Ginder, 1995);(Ben-Daya, 2000); (Cooke, 2000); (Willmott, Peter; McCarthy, Dennis, 2001);(McCarthy and Rich, 2004);(Srivastava and Srivastava, 2004); (Kelly, 2006); (Ahuja, I.P.S.; Khamba, J.S., 2008c)
16	Formation of TPM Office and Steering Committees	(Nakajima, 1988);(Maggard B. N., 1992a); (Bohoris, Vamvalis, Tracey, and Ignatiadou, 1995); (Robinson and Ginder, 1995); (Bamber, Sharp, and Hides, 1999); (Ireland and Dale, 2001);(McCarthy and Rich, 2004);(Srivastava and Srivastava, 2004); (Chan, Laub, Ip, Chan, and Kong, 2005); (Kelly, 2006); (Ahuja, I.P.S.; Khamba, J.S., 2008c)
17	Existing Maintenance System, Equipment and workplace Conditions	(Nakajima, 1988); (Steinbacher and Steinbacher, 1993); (Willmott P. , 1994a); (Mora, 2002); (McCarthy and Rich, 2004);(Srivastava and Srivastava, 2004); (Wireman, 2004)
18	Training and Education	(Nakajima, 1988);(Maggard, Bailey, and Moss, 1989) ;(Hartmann E. H., 1992);(Steinbacher and Steinbacher, 1993);(Willmott P. , 1994a); (Robinson and Ginder, 1995); (Yamashina, 2000);(Ferrari, Pareschi, Regattieri, and Persona, 2002);(Chan, Laub, Ip, Chan, and Kong, 2005)
19	Union Participation and Acceptance	(Hartmann E. H., 1992);(Suzuki T. , 1992); (Steinbacher and Steinbacher, 1993); (Bohoris, Vamvalis, Tracey, and Ignatiadou, 1995); (Robinson and Ginder, 1995); (Cooke, 2000)
20	Pilot Project and Gradual implementation on Model Machines	(Maggard, Bailey, and Moss, 1989) ;(Willmott P. , 1994a); (Bohoris, Vamvalis, Tracey, and Ignatiadou, 1995)(Davis R. , 1997); (Ferrari, Pareschi, Regattieri, and Persona, 2002); (Chan, Laub, Ip, Chan, and Kong, 2005)

TABLE 3.4: A comprehensive list of TPM factors and key authors.

3.13 Implementation phases and steps

Most of the companies that won the TPM Award in Japan had followed a rigorous TPM implementation steps (Mishra, Anand, and Kodali, 2008). These steps were developed by Japanese Institute of Plant Maintenance (JIPM).

Stage I: Preparation

1. Announce top management's decision to introduce TPM.
2. Launch educational campaign.
3. Create organizations to promote TPM.
4. Establish basic TPM policies and goals.
5. Formulate a master plan for TPM development.

Stage II: Preliminary Implementation

6. Hold TPM kickoff meeting.

Stage III: TPM Implementation

7. Improve equipment effectiveness.
8. Establish an autonomous maintenance program for operators.
9. Set-up a scheduled maintenance program for the maintenance department.
10. Conduct training to improve operation and maintenance skills
11. Develop initial equipment management program.

Stage IV: Stabilization

12. Implement full TPM and aim for higher goals.

3.14 Conclusion

As a result of what was discussed in the this chapter, a definition of TPM, from the the Western and the Japanese perspectives, has been given in this chapter. A historical briefing was given, where the roots of TPM go back to the development of Preventive Maintenance, and Productive Maintenance. Then, an extensive review for the literature was performed by the researcher to get a full understanding of TPM implementation and its related issues. TPM at process industry and steel companies were discussed as well. Finally, regarding the objectives of this study, a framework and its components was revealed. The following chapter will demonstrate the case study organisation in the context of Libyan environment.

Chapter 4

Case Study: Organisation Background

4.1 Introduction

Organizational setting and environment tends to be the mirror of probable employee's attitude, confidence, commitment and performance. Furthermore, the local environment tends to have a great impact and generally mould the way how the day to day activities, perceptions, company culture and official relationships are being built in an organizational setting. Besides, it is only imperative to assume that the employee's attitude and activities are significantly reflective of the company's environment and vice versa (Aghila, 2000).

We will be looking at the example of Libya and the geo-political facets of the local economy which might have influenced the organizational environment in the country.

4.2 The geographical, historical and political background

Being the fourth largest country in Africa, Libya became a kingdom adopting the British model of government and got its independence thanks largely to a UN resolution on December 24th, 1951. However, soon, it turned the status of government into a republic regime by September the 1st, 1969. The country is blessed (or cursed) with the oil wealth in its mineral reserves which is a source of improvement in sectors like health and education. The population of Libya was estimated in 2004 by the Libyan census to be around 5.9 million with an annual population growth rate of 2.4 applicable in the year 2004 (Congress, 2005). The country is almost seven times greater in size than United Kingdom, occupying 1,775,500 square kilometres in area.

When talking about the geography and physical features of the country, Libya is mostly desert or semi-desert. The country boundaries are shared with Egypt to the east, Algeria and Tunisia to the west, Chad, Sudan and Niger to the south while there runs a coastal line of two thousand kilometres to the north with the Mediterranean Sea, making it one of the centrally located countries of North Africa. The Saharan desert oriented climate of Libya is somewhat indented on the north by the climate from Mediterranean Sea. It is only essential to understand that the most fertile area of the country is to the north that is along the coastal strip. Further, the Weather of the country is hugely impacted by the country's overall geographical location, where in the southern part, under the influence of the sahara, the climate is generally dry throughout the year with hot summers and cold winters. However, the weather along the northern border, which is under the influence of the Mediterranean sea, is usually hot in summers while

rainy season stretches from December to February on that side of the country (NAID, 2002).

4.3 Libyan society: social and cultural aspects

When it comes to religion and lifestyle related to religious activities, Libya has an edge as the country depict an overall uniformity. It is only Arabic speaking Arab country where the state's official religion is Islam and it is the only religion being practiced throughout the country. Even the sect is being unanimous with all the Muslims following the Sunni faith. It is vital to understand here that Libyans are attached to their religion and their lifestyle portrays their attachment. Moreover, Libyans pay much heeds to verbal communication and commitment and like traditional Arabs, they, too, are adaptable, flexible, social and most importantly hospitable. With such abstracts, being the trademark of their culture, Libyans understandably values their family a lot. Their social and professional culture is marked with the absolute presence of the belonging to a social group. Just like in family and in social groups, the dependency upon the abstracts like trust and reliability also indents their professional lives as well. It should come as no surprise at all that Libyan official and professional culture is quite different from their western counterparts. Instead, of the credibility or name of the concerned parties involved, the professional environment is more dependent on official relationships and friendships among the people, that are built over the years. They believe in social relationship, teamwork, consensus development and are the promoters of the theory that two heads are better than one while resolving any issue in an organization. Religion impacts the overall way Libyans conduct their day to day life and indeed their overall history. The parameters set by the locals as norm of the country and its economy are generally governed and impacted by the religion. Thus, the religion has a huge input in drafting the value system and attitudes of the locals. Other than the religion the social structure of the locals is of high significance as well (Bait-Elmal, 2000).

There are two schools of thoughts in which the current Libyan society is dwelling. Traditionally, Libyans approve that a huge house with three to four generations of the same family living together with married sons along with their families and other individuals living under the same roof. The latest concept of nuclear family system is however creeping into their system with the modern Libya showcasing small families living in separate houses due to work or monetary reasons away from their traditional clan or tribe's setting. As it is the case with most of the Arab countries, Libyan women were used to be confined to their home as late as half a century back. However, things changed rapidly with government and constitution providing for the basic women rights ensuring that women enjoy the same social status and privileges like their male counterpart. They were given right to educate themselves, compete for the same jobs as their male counterpart and ask for the same salaries as well. Law of compulsory education was the first step towards independence of women. This law ensured nine years of compulsory education for every Libyan child regardless of the gender. After the implementation of the law, Libya moved ahead with the exercise allowing women to participate for all job posts and vacancies throughout the country even in the security agencies, police and the army. The need of the law was recognised due to the fact that although women were allowed equal rights in all aspects of the social and daily living aspects but the same was not true practically where the traditional stronger customs would come in between the independence of women as such a small level (Attir,

1985).

The Libyans are strongly attached and devoted to their families and family settings. Usually number of families makes a clan and the total of clans is referred to as a tribe. Like the culture of any Arab county, family, region, tribe and clans are of utmost importance to any individual. Their loyalties to the same cannot be diminished at any cost or political change within the country. They stand with their society and families all the time regardless of the prevailing circumstances or the possible consequences. When it comes to an individual being part of a family, things are even much better with loyalty of the top level involved. The family make sure of the job, security, education and health of the individual which strengthens the individual's ties with his family, feeling as being part of one unit. The individual thus follows, enforces and stays within the laws and regulations, norms and traditions of his family, clan and tribe to show his allegiance to them.

4.4 The cultural transferability

It is important to understand that there exists a marked difference between the culture of Libya as compared to the western countries. Since most of the trading companies and multinational companies has their parent facility based in the western countries, therefore they tend to implement their organization style, environment and management techniques in every subsidiary. Similarly, most of their decision making and evaluation is also based on the management style and traditions and policies that are particular to the parent country. This creates an environment of hostility and differences. Since the Libyans are accustomed to their traditional practices and norm they find it uneasy to comprehend the western style of management. The multinational companies should keep this point in consideration that the difference in culture of the two countries is extremely significant (Aghila, 2000). When investing in the country and applying the company's management style the western countries should realize that the individual society, free economy and the capitalist idea may not go down easily with the Libyan who are more accustomed to team building, families and societal concepts. Thus, it is needed to come at least half way and try to incorporate as much Libyan practices as possible in the management style and businesses. The state religion not only permit but promotes doing businesses. This creates a major breakthrough while addressing the locals. The religion also promotes the concept of hard working, completing the task one is entrusted with and most of all honesty. The religion of Islam also promotes the idea that the leader or supervisor himself should be the role model to those who are following him. He should be responsible and pragmatic.

4.5 Libyan economy

Libyan economy depicts how the wrong practices and corruption can spoil the nature's wealth to its lowest. All that is earned through the export of the oil reserves which accounts for more than ninety percent of the Libyan economy is fruitlessly given away to corruption, ill practices, provision of grants to lesser developed countries by the previous governments and most of all the expenditure on buying the weapons. The government occupies much of the socialist oriented economy and the export of oil accounts for three fourth of the government receipts and thirty percent of GDP. Whatever little trade, imports and exports are conducted there, it is largely occupied and under

the strict monitoring of the government which results in the country turning into a close economy. High inflation, import prices, food shortage, declining standards are creeping into the Libyan society due to the same. Eighty percent of the food requirements are completed with the imports. It is vital here to understand that agriculture though is the second largest sector in the Libyan economy. The government, however, is making efforts to resolve the issue with lifting of the sanctions and making the country attractive for foreign investors by revamping their infrastructure, communication and transportation sectors (Congress, 2005).

4.6 Iron and Steel Industry

The iron and steel industry is one of the most important strategic industries which play a key role in the industrial and economic development. In terms of statistical data showed over the time periods in many countries which have disparate economic level, there was a positive relationship between the amount of consumption of steel products and the economic growth of the state. The progress of countries can be known by the consumption of steel per capita. The number in industrialized countries reached 700 Kg per capita in one year. Arab consumption rose from 19.3 million tons in 2001 to about 27 million tons in 2005, an increase of almost 40 per cent. The per capita consumption of steel products, The gulf cooperation council countries is classified among the most consuming countries in the world consumption of 349 kg per capita. In the Arab world, Arab Emirates ranked the first in terms of per capita consumption by more than one ton per person yearly (Vuuren, Strengers, and Vries, 1999).

Figure 4.1 shows the average of consumption of steel products in some areas in the

FIGURE 4.1: The five largest steel producers in the Arab world (Vuuren, Strengers, and Vries, 1999).

world 2005. The consumption of steel in developing countries is in average of 51 kg

Per capita (1992), and in the industrialized countries is more than 300 kg per capita (Vuuren, Strengers, and Vries, 1999). Figure 4.2 shows the average of consumption of steel products in Libya. The global production of crude steel was declined from 1326.6

FIGURE 4.2: The average per capita consumption of steel products in Libya (Vuuren, Strengers, and Vries, 1999).

Million tons in 2008 to 1219.0 Million tons in 2009, a sharp decline of 8.1%. In 2010, the world production of crude steel recovered and reached a record high of 1400 Million tons. A large proportion of global growth in crude steel production can be attributed to China. In 2010, China increased its crude steel production to 626.7 Mt compared with 573.6 Mt in the previous year. China now accounts for nearly half of world production of crude steel (Nestour et al., 2011). Although the rate of growth in the iron industry in the Arab region is high as it reached 28.87% (2000-2005), but the percentage contribution to the global steel production is still low, which reached to 1.7% of the volume of world production (Thamra and Zwali, 2007).

In the Arab oil-producing, it seems clear that the share of the extractive sector took more inclined upward, while the share of the manufacturing sector declined due to the rapid rise in the prices of oil and raw materials. With a declining share of manufacturing sector in the Arab GDP from 11.20% in 2002 to 9.6% in 2006, the share of the extractive sector is rapidly and steadily. Where, the extractive sector share in the Arab GDP rose from 27% in 2002 to more than 39% in 2006. Libya recorded the same phenomenon, the contribution of the oil sector to GDP increased to 70 per cent in 2006, while the Manufacturing sector's share fell from 3.23 per cent in 2002 to 2.61 per cent in 2006 (Thamra and Zwali, 2007).

In 2008 and 2009, the Arab region has an increasing activity in the housing projects, infrastructure and construction. Unlike most other areas where stopped their expansion projects and building sector because of the repercussions of the global crisis. The demand for steel is still greater than the actual production in the Arab region where, the demand volume for the finished steel products in 2010 is about 35 million tons, while the production in the same year is about 19 million tons, and they expect the volume of demand for steel products in 2014 will reach about 60 million (Lachgar, 2011).

Iron and steel industry in the Arab countries witnessed a huge boom in recent years. The production record rapid growth rate is the highest in the world according to the Arab Union for Iron and Steel. This is attributed to an increase in production of steel consumption in the Arab region, which has become the third largest consumer of steel in the world. It is expected to continue this development in the coming years as a result of the implementation of major expansion projects and the introduction of new technologies that are currently being implemented or expected to be completed in the coming years (Thamra and Zwali, 2007).

Sales of steel products characterized in recent years, by dynamic marketing directed towards the domestic market, in contrast, exports of steel declined to meet the high domestic demand. According to the Arab Union for Iron and Steel, several companies such as, Libyan Iron and Steel were forced to stop exports of long steel products, especially reinforcing and construction steel. Sales of steel products in the domestic market in Libya reached to more than one million tons in 2009 was mostly rebar and building construction, while exports reached nearly half a million tons of different steel products, (see Figure 4.3)(steel, 2009).

FIGURE 4.3: The average per capita consumption of steel products in Libya (steel, 2009).

4.7 Case study organisations

In this section, the researcher would like to shed light on the chosen organisation in the context of Libyan environment, structure of public accountability and administrative system in the Libyan manufacturing public organisations.

It is clear that the absence of positive management, especially in the areas of planning, frequent machinery breakdowns and underestimated levels of maintenance are the important factors affecting the efficiency of Libyan organisations. However, Libya has paid great attention to the manufacturing sector in order to lay the foundations and rules of sound industry according to specific strategies which can activate the role of industry in supporting the national economy, as well as the creation of a real industrial base based on the exploitation of the available local natural resources, and contribute to the absorption of a significant proportion of employment within the labour market each year by maintaining achievement of high growth rate every year.

Therefore, a group of executive programs has emerged aiming at achieving the strategies and industrial policies that focuses on the plans and programs for projects in the areas of iron and steel manufacturing industry, the industry of cement and building materials, food industries and chemical industries.

The iron and steel industry in Libya is considered the most important non-oil industries, and Libyan iron and steel company (LISCO) is one of the most important industrial steel companies in the country having a valuable production that exceeded 1.4 million tons of various steel products in 2008 (Thamra and Zwali, 2007).

After releasing the UN sanction in 2003, which was imposed on Libya in 1992, Libya is seeking to develop its production ability with high quality to meet the customer expectations by the highest technology available (Hirano, Khan, and Hussain, 2008). Moreover, in the context of working to improve the overall performance and benefiting from the experiences of international companies in the field of iron and steel industry, LISCO concluded a partnership agreement with the Holding Company Group ISPAT. The convention aims to use modern methods of management and the means of production to raise the rates of overall performance through increasing production, improving quality, reducing costs as well as satisfying the customer.

Libya as a technology non-manufacturer country, achieved maximum benefit from this kind of agreement by using the technology and prolonging its service life that are attainable only through the pursuit of more effective management methods like TPM, TQM and other philosophies. (Sia and Shamsuddin, 2007) mentioned that most research studies indicate that a well-managed TPM implementation not only enhances the machines reliability and availability, it also improves production output, quality and creates a culture of team-work spirit to own the equipment, while increases individual work skills. According to a previous study about one of the heavy industries in Libya Graisa and Al-Habaibeh (2010) indicated that the marked difference in production over the past years is based on changing in shift hours, the failure of equipment, shortage of spare parts and similar. Also, he mentioned that the result of the analysis showed that there is an urgent need for implementing TPM to maintain a stable level of production. In developing solutions to such problems, there are essential elements

TABLE 4.1: Facilities and products (LISCO, 2010).

must be considered such as strategic planning and the management of the organization's culture.

4.8 Description of Libyan Iron and Steel Company (LISCO)

LISCO is the largest industrial company in Libya, located on an area of 1,200 hectares near the city of Misurata about 210 km to the east of the city of Tripoli. It is fully state-owned company that operates nine large plants with design capacity of about 1,400,000.00 tons of liquid steel per year in a direct reduction of iron pellets using domestic natural gas. The laying of the foundation stone for the company was in 18/9/1979. On 9/9/1989 the opening of the production plants and the company entered the production stage.
The company comprises of several auxiliary and supporting facilities in addition to the facilities shown in Table 4.1, which includes:

1. Port and pellet stock yard.
2. Power and desalination plant.
3. Oxygen and compressed air plant.
4. Sedada quarry and calcimine plant
5. Central workshop.
6. Training center.
7. Quality control laboratories.

4.9 The Development Stages of the organizational structure of the company

The organizational structure of the company (Figure 4.4) is developed depending on the stages of the completion of the project as follows:

- General commission for iron and steel projects (1973-1979);
- The executive commission of the iron and steel complex (1979-1989);
- The preparation of temporary structure in (1989) to complete the procedures to receive the project;

- Libyan iron and steel Company: The organizational construction was adopted in (1993) for the operation of the complex;
- The approved organizational structure of LISCO has been modified in (1998) due to the addition of some development projects and to improve the follow-up procedures, supervision, and increase the pace of achievements.

FIGURE 4.4: The organisational structure of LISCO (LISCO, 2010).

4.9.1 The organizational structure and staffing

The importance of the amendment and the update was demonstrated after several years of operating the plants and the units of the company and through the practical application of the structure and staffing and due to the introduction of other new production units. Detailed study was conducted of proposals of the organizational structure and staffing and issued several decisions on the organizational structure to work out at the beginning of 2000. The number of employees in LISCO is more than 6,700 of whom about 95% are Libyans. The current organizational structure consists of all the sectors, departments and sections in five levels of management (Figure 4.5). The Longitudinal Rolling Plants were established under a contract on a turnkey ba-

FIGURE 4.5: The organisational structure of LISCO (LISCO, 2010).

sis between the General Projects Authority in (LISCO) and Kobe Steel of Japan (KOBE STEEL CO.) On 12/22/1980.

The Headquarter of the longitudinal rolling occupies the third administrative level in the hierarchy of the company.
This department has more than 1,100 employees, including 673 in the operations, about 40 supervisors, 617 technicians, and 10 workers. Further, it includes 427 employees for the maintenance, including 43 supervisors, 35 engineers and 341 maintenance technicians and 8 workers.

Under the scope of this department supervision falls the following units (LISCO, 2010):

1. Operation Department of Bars and Rods Mills (TS-4, unit 1): These sections fall under the supervision of the operation of rolling bars and rods Mills management as following:
   - Operation Division of rolling bars
   - Operation Division of rolling rods
   - Handling Division
   - Control Division
2. Operation Department of Rolling Light and Medium Sectors Mills (TS-5, unit 2): These sections fall under the direct supervision of the operation management of rolling Light and medium sectors Mills as following:
   - Operating Division
   - Handling Division
3. Mills Maintenance Department of Longitudinal Rolling Plants. The Longitudinal Rolling Plants' Maintenance Management is also responsible for direct supervision of each of the following sections:

- Maintenance Division of Cranes
- Mechanical Maintenance Division
- Electrical Maintenance Division
- The Rolling Mills Maintenance Division

The two units (TS-4 & TS-5) have been chosen for the case study of this research due to the fact that the TPM program application in LISCO has been already initiated in these two plants. A brief description of these two units is considered.

Bars and Rod Mill (TS-4)

This plant consists of two lines to produce bars with designed capacity of (400,000 tons). The first line was commissioned on 12.10.1988, while the second line started on 18.02.1989. Also, in 1997, a double strand line was implemented, with an annual designed capacity of (400,000 tons), it has started operating on 27.05.1998 (Figure 4.6).

The Bars and Rods Mill produce round bars with diameters between 12 and 40 mm,

FIGURE 4.6: The TS-4 steel products types in LISCO (LISCO, 2010).

and rods with diameters between 5.5 and 12 mm, and square bars with diameters 10, 12and 14 mm, with different steel grades varying in chemical composition and end users.

The bars production process involves heating of billets to about $1200C^{\circ}$ and rolling in three stages, roughing, intermediate and finishing, followed by air cooling on the cooling bed. The rod production process also take the same way, but followed by Stemmer water and air cooling to control the final properties of the product.

Light and Medium Sections Mill (TS-5)

Entered the stage of commercial operation on 08.04.1989 with an annual designed production capacity of (120,000 tons) of light and medium sections in various sizes and dimensions. The Light and Medium Sections Mill produces different types of sections. The production process involves heating of blooms to about $1200C^{\circ}$ and rolling in three stages, roughing, intermediate and finishing, followed by air cooling and straightening (Figure 4.7).

FIGURE 4.7: The TS-5 steel products types in LISCO (LISCO, 2010).

4.10 The state of the company and the production

LISCO is an ISO-certified integrated steel plant and has won awards for quality from European bodies and entities. Because it is a cheap and an environmentally friendly, LISCO uses the local gas as fuel for production. LISCO use Brazilian, Canadian and Swedish steel pellets as raw material.

Chairman of LISCO pointed out that the Company, as it stands today, is in good position. He added, right from the beginning of 2002, with the restructuring in economic policies of the country, we started improving and even made a profit and in 2004, our profits exceeded 100 million LYD, and I feel that the company is in good shape at the moment. Further, we export more than 60% of our final product of mixed type, while the current policy of the company involves selling most of our reinforced bar production in the local market. The domestic industry consumes about 25% of our flat products, while the rest is exported. Our biggest local client is the General company for piping situated in the Libyan coastal town of Benghazi. The rest goes to the private sector and some oil companies. About 50% of our exports are directed to Italy and Spain. The rest is spread around countries like Tunisia, Egypt, China, and France. Our return on exports in 2003 was $ 165 million and $ 275 million in 2004. In 2005, up until 15th of September, our return so far is $ 165 million, and expected to reach $ 250 million by the end of 2005. The turnover jumped to more than LYD 560 million last year. In 2003, it was about LYD 385 million, and so far this year it stands at LYD 470 million. Our costs of production have risen this year, due to the prices of imported raw materials (pellets) that have increased by 90%. Meanwhile, prices of final products compared to last year, were reduced by 40%. As for this year's production, we have on this very day reached one million tons of liquid steel (Mabrouk, 2005, September 18).

LISCO's products in last years have met most of domestic requirements for rolled steel. LISCO's products have also found their way into foreign markets worldwide. The yearly quantities sold by LISCO in the last years in the international markets are as shown in Table 4.2 below (LISCO, 2010). Figure (6) shows the Company production.

4.11 Overview of the steel making process at LISCO

The process of the steel making at LISCO is a long process begins by downloading the raw materials that arrived at the port. The primary ingredient in LISCO processed steel is oxide pellets (iron ore) this material arrives from various suppliers from around the

TABLE 4.2: Export production of LISCO (LISCO, 2010)

FIGURE 4.8: LISCO Steel Production (LISCO, 2010).

world. Each supplier supplies a different quality and with different chemical composition. The iron ore, therefore, must be stored in separate piles based on supplier. The next step, the oxide pellets are reclaimed into a conveyor by the stacker/reclaimer. The oxide pellets travel to the direct reduction (DR) plants, which consist of three Midrex Direct Reduction modules, two for direct reduced iron (DRI) production with a total annual capacity of 1,400,000 tons, and one modules for producing Hot Briquetted Iron (HBI) with a capacity of 650,000 tons annually.

The oxide pellets are charged into the reduction furnaces from the top. Hot reduc-

FIGURE 4.9: Production of molten steel (LISCO, 2010).

ing gases (CO and H2) are pumped into the reduction furnaces to extract the oxygen from the oxide pellets. "Reduced" iron ore or "sponge iron" leaves the DR plants from

a chute in the bottom and travels to a silo until it is needed in the melting plants. Natural gas is piped to LISCO directly from Libyan gas company. converting iron ore into metallic iron, oxygen must be removed from the ore. this processes requires heat and a reducing agent, a substance that combines with the oxygen that is released (Figure 4.9).

The next step is at the Steel Melt Shops (SMS1) and (SMS2). SMS(1) Consists of three electric arc furnaces 90 tons each, two Billet casters and a Bloom caster. The shop has a design capacity of 630,000 tons/year of Billets and Blooms. Similarly, SMS(2) consists of three electric arc furnaces 90 tons each , and two Slab casters. The shop has a design capacity of 611,000 tons/year of Slabs . This process begins with opening the lid furnaces and the scrap iron is dumped in, as well as HBI and the additions of some other materials. Power is applied in the Electric Are Furnaces.

Essentially, the scrap melt causes a short circuit, lots of noise and light, and heat is gen-

FIGURE 4.10: Steel casting and Hot Rolling (LISCO, 2010).

erated. This molten steel to come out in the form of billets and slabs, the molten passed several operations. After the molten steel was poured in to ladle, it goes through the flow control dish, and then to the Mould. After that it will start the process of cooling and it is heading for a rolling process. The output of this stage, which is billets, bloom and slabs, is the input to the next stage which is the final stage of the manufacture of iron and steel (Figure 4.10).

4.12 The journey of TPM in LISCO

Decision No. (212) of the year 2006 was issued by the Secretary of the Management Committee, and decision No. (111) of the year 2007, and its amendments by decision No. (109) of the year 2008 concerning the formation of a committee to oversee the implementation of TPM on all the plants and facilities of the company.

TABLE 4.3: Rolling mills production and stops rate (LISCO, 2010)

Since the TPM is a comprehensive approach aims to establish and strengthen the industrial culture and leads to an overall higher efficiency of plants and production lines and equipment through working on the reduction of all types of losses and continuously improving the performance of employees and equipment in order to achieve the products at an acceptable cost and high quality and satisfying customers.

Global industrial companies have adopted this strategy in order to meet the challenges of rapid technological developments and increase their competitiveness in the global market by relying mainly on the development of its human resources. Henceforth, LISCO initiated the adoption of this methodology by issuing declarations to start the program at the beginning of 2007, seeking for successful implementation in order to achieve integration with both quality and environment, and accessing to higher overall effectiveness of its productive system, taking into account that the base of the success of TPM depends entirely on the provision of senior management's full support, awareness, training programs and other activities required according to the pillars of this program through the establishment of the necessary structural for the rehabilitation of plants and the company to gain international TPM certificate, which is issued by the Japanese Institute for maintenance plants (JIPM) after passing audits.

The TPM teams have been formed in each plant to deal with the selected model machines according to the schedule indicated by the master plan. The structure of the application (implementation committees and task forces) formed in accordance with the structures of pillars implementation of the program factories and units. Where the manger of operation department was adopted as chief of autonomous maintenance, and the manager of maintenance department as chief of planned maintenance, and also this matter applies to the rest of the chief pillars, where the head of safety department was assigned as chief of health and safety pillar, and the head of engineering as chief of focus improvement pillar.

Four pillars out of eight, that have been applied in the TPM program as recommended by the consultant autonomous maintenance, planned maintenance, focus improvement, and safety, health, and environment. The fifth pillar, training and education was added later. Practically proceeded to apply the program to all the plants and units of the company through the selection of the number (50) model machines, and number (25) focus improvement projects to treat the causes of loss in productive process, which will be with the participation of the company ISPAT, which is the engineer partner of LISCO, under the auspices of supervisory committee and the higher committee and consulting specialized firm, following the implementation of a comprehensive awareness campaign for all employees. After a period of time, the number of model machines was raised to (100) equipment.

The impact of starting TPM implementation on the production was not great as it is

known. Where production rate is mostly expected to be less at the beginning of the implementation, as a result of the efforts of the workers being made in non-productive activities such as acts of cleanliness and sort, among others. The production rates and the proportion of stops for Longitudinal rolling mills indicate that 2008 is better than previous years and Table 4.3 shows the percentages and years. The following is a review of the main activities of the commission to oversee the implementation of the program during the year 2007.

January

- Composition of the committee overseeing the implementation of the program.
- Developing the practical steps for the program.
- Determine the duties and tasks of the coordinators within the organizational structures of the application.
- Calculate the overall plant efficiency of the steel plant (2) to take it as a reference.

February

- Selection of model machines.
- Forming the continuous improvement teams.
- The application of the five bases in the region of the defect.
- Initiate the preparation of periodic and leaflets on the activities of TPM.
- Processing of the curriculum of the training program and begin training.
- Proceed with the implementation of the awareness program.

March

- Initiate improvement activities within the workplace.
- Using leaflets on AM, PM and Education and Training.
- Initiate implementing the five pillars.
- Determine the sixteen losses.

April

- Preparation of the development of the company's policy towards the TPM.
- Division of the plant to the areas for the purpose of an audit in the cleaning (5S).
- Preparing some mobile boards to highlight the activities on model equipment on the plant.

May

- Prepare an outline for the AM
- Identify targets for the TPM program in the steel plant 2.

June

- Including a Single Point Lessons in the awareness sessions.
- The formation of sub-committees in accordance with the organizational structure of the plant.

July

- The formation of the Higher Committee for the TPM program.
- Determine the number and classification of equipment as a priority.
- Using Why- Why analysis for the model machines.
- Implementation of a series of workshops about 5s, AM, PM and continuous improvement.

August

- The launching of the system of initial incentives to improve the workplace.
- Prepare an outline timetable to complete the implementation of the activities of autonomous maintenance of the equipment model.
- Assess the skills of participants in terms of training and education.
- The preparation of a training course on the principles of safety.

September

- The preparation of the interim standards for the autonomous maintenance of the equipment model.
- Initiate the preparation of a initial standard for cleaning and inspection methods.
- Implementation of a series of workshops about planning maintenance.

October

- The consultant visit.
- Implementation of specialized workshops for autonomous maintenance teams.
- The preparation of curricular for the awareness of leaders.
- Provide the department of the industrial safety with requirements of the principles of safety and health and the environment to be added to the current safety sessions.

November

- Improve the visual management in the plant.
- Evaluate the first step of the autonomous maintenance by the operators for the model equipment on steel plant 2.

December

- Implementation of a series of seminars to aware the leaders of production sector the concept of TPM.
- Evaluation of the results obtained by the application of the 5S in the workplace.

4.12.1 Main activities summary and results of TPM in 2008

Table 4.4 below summarizes the main activities of the supervise committee and the results of the TPM in 2008. This table shows that is under the guidance of the consultant and supervision of TPM committee in LISCO, the target and the achievement of the TPM activities in 2008. It shows the starting TPM pillars, TPM awareness sessions, the plants interning TPM program, supporting facilities, and workshops those entered the application stage. Furthermore, this table displays the number of model machines that were selected to start with in this TPM program, projects for focused improvement, and the plan of the consultant visits.

TABLE 4.4: Summary of the main activities of the supervise committee and the results of the TPM in 2008 (LISCO, 2010)

4.12.2 Gantt Chart

A Gaunt chart was developed by LISCO, as shown in Figure 4.5, in order to maintain the pace of the TPM program in LISCO. It shows the phases for entering the plants of LISCO in the TPM implementation program from start to finish. A detailed timeline for the actual project start to implement the program in the various plants of the complex, including the plants of the case study, in addition to the dates of the planned visits of the project's consultant. The chart is used to compare the current status of the different phases of the implementation starting with the preparation of the self-maintenance steps to be implemented on the module machines, passing through the application of the horizontal replication extension to the rest of machines, before ending with the phase of stability of the application in plants and conducting the final audit to obtain the upgraded TPM certificate which was expected (at that time) to finish by the end of 2012.

TABLE 4.5: Gantt chart of the scheme to enter the plants to the stages of implementation of TPM (LISCO, 2010)

4.13 Conclusion

The chapter contains a brief evaluation and briefing of the general Libyan environment and the environment of the Libyan Iron and Steel Company (LISCO), specifically as a case study for this research. The environmental factors seemed to be influencing various other factors within organisations like the employee satisfaction, dedication, employee's overall productivity affecting the attitudes and perceptions of the people of the organisation (Aghila, 2000). This matter can be further brought under discussion later in other chapters.

The Libyan environment has been brought under discussion in the context of geographical, political, historical aspects along with considering cultural and economic aspects and population and workforce. It was highlighted through the research, specifically through this chapter that the Libyan culture and societies still contain that families and tribe system with a kind of hierarchical system prevailing with strong bonds and close relations. Moreover, Islamic rules and regulations have an influence over these families and tribes of Libya and their life styles as well. Further, Arabic and islamic rules, cultures and values are the most significant factors for individuals and groups as well, which can be observed within their attitudes, perceptions, beliefs, laws, life styles and the political and economic system. Another factor that can be considered that is responsible for shaping attitudes and perceptions of the Libyan population is the Libyan economy factor.

In the following chapter, data analysis chapter, related to factors affecting TPM implementation from the case study organisation, will be highlighted and presented in the relation of the Libyan environment context.

Chapter 5

Data analysis

5.1 Introduction

This chapter presents the primary findings of the empirical investigation carried out within two manufacturing units at the case study organisation (LISCO) in the Libyan manufacturing environment. Semi-structured interviews were the main source of data for this study in addition to the questionnaires, reviewing documents, such as minutes of meetings and TPM work sheets. Consulting firm reports were also used to substantiate the interviews. The findings will be presented in relation to the aims and objectives of the research to answer the research question. The main part of this chapter presents the interviews' results, followed by the questionnaires and documents' results, which were used mainly to supplement and triangulate the data of the in-depth interviews.

5.2 Interview results

The interviews were conducted during the period from June to September 2009 and from December 2010 to January 2011. The time allocated for each interview fluctuated from case to case, and in general, the average time was about one hour. The researcher used interview protocol as a research instrument. The researcher believes that the chosen sample for interviews is sufficient to represent the data required for this study. Considerations were made to ensure that those selected to be interviewed would represent the main departments and people which are very close to TPM activities, and their positions allowed them to have a good knowledge and information related to this study topic.

The numbers of interviewees in both case study organisations were 7 and 6 persons respectively. This is in addition to the interviews conducted with the TPM directorate committee. They were distributed through three management levels (Table 5.1): level one (LI), includes top management and seniors of TPM. Level two (L2), includes, TPM pillars chiefs, managers and supervisors. Level three (L3), includes the members of small group activities. Covering these three levels enhanced the validity and reliability by getting responses from different points of view, which means triangulating peoples' opinions.

Management Level	Sample Size		
	TS-4	**TS-5**	**TPM**
Top Management	2	2	1
Middle Managers	5	4	5
Activities members	4	4	0
Total	11	10	6

TABLE 5.1: Interviews sample size for different management levels

5.2.1 The interview Questions

The interview questions were prepared by the author and they are annexed to this thesis. However, hereinbelow the questions mentioned therein are listed:

Understanding Total productive Maintenance and its benefits

- What is the importance of understanding TPM program in your organisation?
- What are the benefits can be achieved from implementing TPM successfully?

Top management support and commitment to TPM

- Do you think that top management support and commit to TPM?
- To what extent do top management support TPM in your organisation?

Managing TPM activities

- What are the pillars of TPM that were implemented in your organisation?
- In your opinion, what are the TPM pillars could be suitable for your organisation?
- How the focus improvement projects were chosen?
- How do you deal with the focus improvement projects in your area?
- Do you use any support tools while implementing TPM, e.g. OPL, Why-Why analysis?
- In your opinion, what are the support tools and techniques could be suitable for your organisation?

TPM performance

- How do see the TPM performance in your area?
- Are there any publications of TPM performance?

The organisational policy and socio-culture impact

- In your opinion, are there any political, economical, or socio-cultural issues that affect successful implementation of TPM?
- How would you describe the bonus, recognition and wage system in your organisation?

- To what extent are the employees and managers involvement on TPM?

Management information system and Communication network

- How satisfied are you with the cooperation coordination between all departments of the organisation, and the level of communication network?
- How would you see the management information system in your area?

General questions

- What do you think about TPM generally?
- Can you please describe what you see necessary to implement TPM successfully?
- Using the following table, Please specify how important do you think the following factors to implement TPM successfully in your company?

The replies for each question for both units are detailed next.

5.2.1.1 Understanding TPM and its benefits

The main key regarding the way of dealing with any issues, from the researcher's point of view, is by understanding and knowing them in the first place. Hence, in order to grasp a good understanding of TPM systems and profit from all CSO employees, the researcher used open questions:

what is the importance of understanding TPM program in your organisation?

This is concerning: the managers' point of view in understanding TPM systems and its benefits. Respondents showed that a number of education/training programs were conducted to managers, but unfortunately, with a quite limited scope. Indeed, the results showed that the top managers in both case studies did not get involved heavily in these programs because they were very busy claiming that such kind of programs concerns more the middle managers. This matter led the top management to be less eager in attending or participating in these training/education programs related to TPM strategies. Therefore, results revealed that top managers have only a limited general understanding and idea about TPM and unaware of its benefits to the organization.

However, the majority of middle management staff agreed that the TPM program have made a positive effect on both the disciplinary and consistency of the staff in the organization, whereas, few respondents did not recognize any difference and believed that work is running as it was prior to the application of TPM strategies.

What are the benefits that can be achieved from implementing TPM successfully?

In order to enquire into the views of interviewees with regard to the question in subject, the question if both units have achieved better performance after the implementation of TPM within them was asked. The majority of respondents from middle managers as well as TPM office gave the answer that a general improvement was noticed within both units. For example, waste reduction in production and in the assistant materials, development in personnel skills, safety level, building teamwork spirit between the employees, and production quality improvement.

5.2.1.2 Top management support and commitment to TPM

In reply to the question:

Do you think that top management support and commit to TPM?

In both case studies, in relation to the question if there is top management commitment, the interviewees do not see sufficient support from top managers, they believe that the managers do not have a very good ability to lead an organisation to achieve its objectives, most respondents from middle managers and supervisors have said that there is no effective leadership. Some respondents confirmed that, actually the wrong people are in the wrong positions due to their qualification and experience.

In reply to the question:

To what extent do top management support TPM in your organisation?

The majority of respondents, in both case studies, believed that the top management are eager to embrace the idea of TPM program, however, this eagerness lacked the sufficient commitment and support. On the contrary, few respondents thought that the top management showed sufficient commitment and support towards the implementation of the program. Moreover, these few believed that top management were very concerned about getting a certified TPM award for their organization.

5.2.1.3 Managing TPM activities

TPM aims for the participation of all the workers from all levels of work to solve the problems of equipment and improving them, especially those workers who deal directly with the equipment. Therefore, the activities of small groups play an important role in TPM. Small groups means the formation of small teams of workers who deal directly with the equipment in order to solve a problem, to develop the equipment, and to develop the work environment. Through TPM office, a master plan is adopted with the participation of TPM consultants, where the suitable pillars are selected and also studying the equipment to be included in the continuous improvement projects. As well as, identifying the support tools for the activities and pillars of TPM to help get great results of the implementation. According to the question:

What are the pillars of TPM that were implemented in your organisation?

Consistency and repeatability of the methodology is one of the main important requirements for the success of TPM. (Pomorski, 2004) referred that the key elements of TPM are known as “pillars” and sometimes they are called activities.

All the respondents answered this question referring to the master map that was used for implementing TPM in LISCO. After declaration by top management and awareness of the top management, the five pillars were activated, i.e., Autonomous Maintenance, Planned Maintenance, Focus Improvement, Safety Health and Environment, and Training and Education.

According to the question:

What are the TPM pillars that could be suitable for your organisation?

With lack of understanding of the participants to TPM, there were some who said that they must have deployed activities based on the five pillars of TPM focusing on the production site. The majority of respondents agreed that autonomous maintenance and planned maintenance are the best pillars that fits in their area. However, TPM office members believed that the first five pillars are very important to implement TPM successfully.

Respondents were asked:

How does the focus improvement projects were chosen?

This activity have small groups of employees work together pro-actively to achieve regular and incremental improvements in the equipment operation that had an identified recurring problems and was resolved by cross-functional teams. It, also, combines the collective talents of an organisation to create teams for continuous improvement.

In both cases, the answer was not clear, due to the misunderstanding of TPM. On the other hand, some of the respondents agreed with the general regulations of choosing the focus improvement projects. These projects, that are dealt with by the TPM-team, are selected by three different ways: first by a Pareto-analysis of the equipment. Then, the team will search for the root cause of the problem. Followed by an Ishikawa-diagram to map the causes and consequences in a fishbone structure. Second way, cost and volume deployment techniques were used to identify areas where focussed improvements were carried out and to help identifying what techniques were applicable. Third way, an ABC classification system that gives priority to machines for production and maintenance. For example, an A class equipment is one which is a bottleneck on a particular production line and there is no replacement equipment if it breaks down.

According to the question:

How do you deal with the focus improvement projects in your area?

The respondents replied “not enough” after identifying the projects using ABC classification system. This system gives priority to machines for production and maintenance, for example, an A class equipment is one which is a bottleneck on a particular production line and there is no replacement equipment if it breaks down, then the TPM-team will detect a root cause of a problem, then they will send a proposal for a resolution to their senior management for restoring equipment to its prime operating condition. All that has been mentioned by the participants as mere words only. Completion rate of projects is not satisfactory.

According to the question:

Do you use any supporting tools while implementing TPM, e.g. OPL or Why-Why analysis?

From the interview with both units (TS-4,TS-5), all middle managers and activities' members agreed and stated that TPM needs supporting tools to be implemented successfully. So, every stage of implementation and every activity has a different tool. In general, some respondents informed that there is insufficiency in using methods and supporting tools. They attributed this insufficiency in some areas to the lack of top management's sufficient care and support, e.g. giving space and time to do OPL, or to hang the activity board, and also it is due to the obscure view of the organisation as a whole regarding this issue. Furthermore, others insinuated that the insufficiency is in the supporting tool and methods of application and recommended to enhance such methods and tools in order to facilitated the application of TPM program successfully.

According to the question:

what are the supporting tools and techniques that could be suitable for your organisation?

The answer to this question varied from respondent to other, but what was agreed upon is that the identification of the supporting tools for TPM implementation will be based on the recommendations of TPM Office and TPM consultants, for example, during the application of autonomous maintenance steps, the one point session, tagging, and visual controls can play a critical role in the 5S process by providing an effective tool for eliminating clutter and organize the work area. Activity boards are one particular type of visual control that are typically used in TPM. The JIPM refers to activity of the plates as a guide to action. Poka-yoke also plays an important role for safety and human error.

5.2.1.4 TPM Performance

In reply to the question:

How do you see the TPM performance in your area?

Managers and middle management supervisors at both units gave their opinion about different performance measurement aspects utilized in their organizations. Respondents showed that the current organization's performance measurement tools are limited to job and time sheets, in addition to reports only. This is indeed an indicator of weakness related to the way of monitoring the TPM performance by utilizing only reports to follow the activities of the department rather than having an indicator of the target achievement.

Furthermore, the current system, according to the respondents, fails to measure the effectiveness and efficiency of the department activities, though it is just a series of unrelated and inconsistent measures that employees have to undertake without adding any value to the organization.

In reply to the question:

Are there any publications of TPM performance?

The respondent from the top and middle management mentioned that there is a monthly magazine published by the company which is interested in the activities and decisions of senior management as well as the activities including labour creativity and inventions. All this in addition to the brief on the proportion of output and productivity growth rates for some of the factories of the company. There is also an annual report comes out from the management of research and development of the company that gives every indication of productivity and wastage including stoppages and defective rates.

5.2.1.5 The organisational policy and socio-cultural impact

In reply to the question:

In your opinion, does the company have an effective suitable organisational policy?

The answer mostly was "yes". The participants noted that the regulatory policy of the company recently became better and does not rely on the old management philosophies. In fact, improvements has been made in the organization policy and has brought real changes to the organization's laws and regulations. However, the respondents also believed that there exists a bureaucratic behaviour in the organization that made all the commercial activities very difficult due to the fact that such bureaucracy may affect the organization's performance and hinder improvements.

Further, there answer revealed that there is a general resistance to the change by operators and maintenance personnel due to the new tasks assigned to them, and the redefined roles of both departments. Production people considered it as an unfair and one-sided decision that they have to share the maintenance work while the maintenance people do not have to share the operators's job. In some cases, it could be noticed that people did not accept the TPM concept because they thought that TPM would try to increase the operators' workload with the goal to run the organization with fewer maintenance people. Moreover, the answer showed that maintenance people did not consider operators' training and the establishment of autonomous maintenance as their task and target.

In reply to the question:

How would you describe the bonus, recognition and wage system in your organisation?

When exploring the views of respondents about the rate of salary / wage, compared with the average standard of living, and all the participants in both units of the case study, they indicated strongly that their current salaries are low, but compared to the other companies in the industrial sectors, salaries are considered reasonable. Some respondents noted that there is an annual profit distributed on all members of the company. This profit in 2008 reached more than LYD 8000 per worker (about \$6000/worker). However, in general, there is not a good system of wages and motivations.

In reply to the question:

To what extent are the employees and managers involved in TPM?

Answers revealed that the amount of occupation and concern of employees and managers regarding the TPM programs within both units is entirely dependent on the way these programs are initiated and how techniques and procedures are handled and applied, such as the selection of the number of model machines.

Some of the respondents within the two units agreed about the existence of some kind of conflict in the performance of certain jobs in the maintenance department. This conflict takes place between engineers, technicians, maintenance personnel and operators. These conflicts are due to unclear and ambiguous distribution of tasks between these people during the performance of some maintenance tasks.

In reply to the question:

To what extent are the employees and managers of both production and maintenance empowered?

Respondents noted that, practically, the empowerment was fastened and chained by the current laws and regulations of the organization in such a way that it completely depends on the point of view of the middle management appointed by the government, leaving only a very tight area of authority to the employees.
Moreover, respondents reported that the mid-management is under the control and the direction of the government, and hence their empowerment, of course, relies mainly on the empowerment of managers themselves. As a result, the empowerment of employees is controlled and biased by the government as well.

5.2.1.6 Management information system and communication network

Communication was and still is a very important activity in the field of business; Moreover, communication has become the backbone of any company, and will be so in the future too.

In reply to the question:

How satisfied are you with the cooperation and coordination between all departments of the organisation, and the level of communication network?

Respondents at both units mentioned that there were a general welcoming from all people by the mutual cooperation and coordination between all relevant departments within the organisation. They said, “We, as Libyan people, prefer to work in a collective climate and accept to assist each other, however, due to some managerial difficulties and unsuitable arrangements, coordination and cooperation have not been addressed officially and sufficiently”. The difficulties according to the respondents included the non existence of clear procedures to follow, no determination of the boundaries of authorities and responsibilities in the related overlapping departments, the lack of enthusiasm and promotion from some managers at different levels, and the shortage of cooperation and coordination facilities, e. g. methods and devices. Sometimes the enthusiasm of people to work by the spirit of team faces some obstructions when some managers and/or supervisors do not like to work with people from other departments

or/and units. Therefore, it depends on the mood of those persons, as there is no clear 'official' rules that organise the mutual processes. Some people considered the participation from other departments or units as an intervention in their jobs, however, the others welcomed that contribution and facilitated its conducting.

In reply to the question:

How would you see the management information system in your area?

The respondents from both units mentioned that, there was not only a typical paper-based information system. they have intranet network between all the departments. Some respondents mentioned that the process of establishing a new management information system is carried out. It was noticed that internal communication networks in the company are as good as the external communication networks. All respondents agreed that the external communication network was effective in LISCO.

5.2.1.7 General Questions

In reply to the question:

What do you think about TPM generally?

All levels said after explanation to them what TPM is about and from the questioners nine mounts ago TPM would be very helpful because everything will be done correctly right from the start with the TPM principles. Employees said we are ignored by the company and are not managed as assets with no opportunities for involvement. Furthermore, employees' knowledge, experience and ideas may improve the business strategy and may secure a good practical implementation. Employees in all levels in the company need to make sure that their leaders want them to participate. They need to know that their leaders are willing to listen to them, support them, and remove barriers to their ideas. They said the top management should make sure that everybody within the company from top to bottom is clear about the long-term goals. This affects management style, quality of communication and indeed everything that is done within a company. From the employees responded the question to the second levels and middle managers about the idea and the comment from the employees. The middle managers and first line managers' responses from both units argued that employee involvement and empowerment in decision making was demonstrated in the shop floor. And should be rewarded to encourage responsibility to make decision, but power and authority to make decisions! Meaning high scores on the power distance dimension and the boss is always right and high centralisation of power. The employee can take his decision to stop the production process if anything unusual happened and then call his supervisor to discuss with him what he should do.

The feedback from the middle management respondents in, company highlighted three reasons for not having enough TPM knowledge mentioned below:

- Lack of knowledge about TPM and culture, and no good TPM awareness programs have been introduced to them inside the company.
- No opportunity was given to them from top management to attend training course and workshops in the field outside the company.

- The chance to attend the training programs related to TPM is given.

In reply to the question:

What are the main obstacles facing the implementation of TPM successfully in your organisation?

From the interview with the maintenance and production managers about the barriers effecting TPM to be implemented, it was event that if correct implementation should require manpower resources and top management commitment of training and educate them about TPM concepts and principles. In both units, staff considers that the management representative as a general director is responsible to bring TPM awareness to them, knowing areas needed improvement, provide resources required by the system and can guide the company during all processes for TPM.

In fact, the middle manager in both units indicated that appointment of the general director as a management representative was a barrier affecting implementation of TPM because the management representative is responsible for ensuring that the TPM is appropriate, is responsible for promoting the program awareness, to monitor the performance of the system and needs to report formally to the management review team. In addition to those barriers, management may encounter the problem of not considering TPM as continuous programme. From the all top managers said employees and middle managers to put across their dissatisfaction by delaying or neglecting in doing something. From the interviews in both units in all levels mangers fail to clearly understand the concept and the philosophy behind TPM.

From the interviews, first-line managers traditionally has been as the authority within a particular department on site (e. g. operation team, work supervisor). They are responsible for telling the workforce what to do and they are very confused to put another way in the job. This meant that the company sets unreasonable objectives and lack of understanding of each others' perspectives. The success of a TPM programme depends on supervision being given the tools, skills and ability to manage the process.

In the end of each interview, the researcher asked the respondents using the following table

Please specify how important do you think the following factors to implement TPM successfully in your company? (see Table 5.2)

5.2.2 The interview findings

The findings that are identified during the interviews in both cases could be summarised as follows:

- There is a need for clarifying the importance of understanding TPM program.
- No clear knowledge of the benefits behind implementing TPM.
- No effective leadership.

NO	Key Factors	Not important at all	Not important	Neither important nor unimportant	Important	Extremely important
1	Management Commitment					
2	Employee involvement					
3	Motivation, Rewards and Recognition					
4	Time allocation for implementation					
5	Resource allocation for implementation					
6	Alignment to company mission					
7	Performance measurement					
8	Implementation plan and process					
9	Effective Communication					
10	Integration with other manufacturing management programs					
11	Cooperation					
12	Coordination and leadership					
13	Cultural Change, Knowledge & Beliefs and acceptance					
14	Availability of information and Documentation					
15	Empowerment					
16	Formation of TPM office and Steering Committees					
17	Existing Maintenance system, Equipment & workplace Conditions					
18	Training & Education					
19	Union Participation & Acceptance					
20	Pilot project and Gradual and implementation on model machines					

TABLE 5.2: Specifying how important are the TPM factors.

- Senior management's willing to adopt TPM concept is not commensurate with the support of the implementation.
- First five pillars implemented are for the production site, which were recommended.
- Not dealt seriously with the focused improvement projects.
- There is poor use of support tools while implementing TPM.
- In early stages of implementation the measurement of TPM performance is very difficult.
- The activity board and the monthly magazine do not cover the activities and results of the TPM implementation.
- Changes in some of the organisation's policies affect the efficiency of the application.
- The operators see TPM as overload task.
- Maintenance personnel are uncertain about their job security.
- There were profits and bonus, but still not good system of wages and rewards.
- Lack of involvement in management decision leave with a bad impression Therefore participants.
- The empowerment were limited.
- There are some individual attempts to creativity from some of the participants.
- There is lack of cooperation and coordination in the organisation.
- The communication level is very poor and very bureaucratic.
- Despite the existence of a maintenance system, but the maintenance data are not recorded in the correct way and training is required.

5.3 Document review results

One of the key methods that was implemented in this research for collecting the empirical data, was the relevant documents analysis as well as accessing the archival sources of the organization. These sources included all the files, reports, records, and worksheets relevant to the different levels of the organization.

The author was granted permission by the TPM management to freely access most of the relevant material acquired. Such material included the decisions and regulations regarding the structure of the organization, the correspondences of the company, the appraisement manuals, the monthly and annual TPM reports, and the minutes of meetings related to different management levels. Further, some of the documents were obtained in original copies, while others were obtained as a photocopy or short notes describing their contents and formats.

This part of the research deals with what has been reached by analyzing the content

of TPM reports and the consultants' TPM observation reports, as well as, periodicals published by the company which explore the activities of workers and work-teams and progress meetings with the heads of departments including the office of TPM.

From all of the above, important results were reached that can triangulate with the results of the interviews and the questionnaires in order to answer questions about the search. The results of the documents survey can be summarized as follows:

- Awareness of the concept of TPM, where an awareness courses were implemented in the training centre by instructors who have been groomed and with the participation of the supervisory committee. The number of employees who have been sensitized on company-wide was about 3932 employee out of a total of 6680 employees.

- All ten plants in LISCO have been introduced to TPM program. After trying a single application on steel plant 2, continued for a year, the program has been re-implemented, but collectively on all the company's plants.

- Four pillars out of eight have been applied in the TPM program as recommended by the consultant, namely, autonomous maintenance, planned maintenance, focus improvement, and safety, health, and environment. The fifth pillar, training and education, was added later.

- From documents review to working sheets and TPM documents, it turns out that there is a need to use some tools to support. These tools were used in line with each pillar. E.g. the one point lesson (OPL) was used in autonomous maintenance, and why-why analysis was used in focus improvement. Also the 5S's used with visual control tools to remove clutter and organize the workplace. Mean time between failure (MTBF) and Mean time between repair (MTTR) used to calculate OEE. For organisations that are new to TPM implementation, two measures that may be of equal benefit, but less agonizing to collect data for, are MTTR and MTBF. Both MTTR and MTBF are simple measures to calculate, but very powerful when used to measure equipment performance. MTBF can be calculated by simply dividing the (uptime /number of stops) of the equipment. Whereas, MTTR can be calculated by simply dividing the (downtime/number of stops).

- Tagging is problem communication tool to and from maintenance, and production Identify abnormal machine conditions. Record problem discovered by operator; Record problem found during scheduled PM; Status tracking system of requested repairs; TPM visual management tool (hang tags); Repair history for future problem solving; TPM Tag used for recording problem & fix, where they

use red and white tag.

- Model Machines, 50 equipment were chosen from all ten plants of the company as model machines, where such equipment have been selected on the basis of classification according to the degree of importance and bottlenecks. After a period of time, the number of model machines was raised to 100 equipment.

- Teams work, TPM teams have been formed in each plant to deal with the selected model machines according to the schedule indicated by the master plan. The structure of the application (implementation committees and task forces) formed in accordance with the structural of pillars implementation of the program factories and units. Where the manger of operation department was adopted as chief of autonomous maintenance, and the manager of maintenance department as chief of planned maintenance, and also this matter applies to the rest of the chiefs pillars, where the head of safety department was assigned as chief of health and safety pillar, and the head of engineering as chief of focus improvement pillar.
- Follow-up focus improvement projects in accordance with the matrix loss in each productive unit, so (25) focus improvement projects were selected by implementers, and represent the most important elements of the loss. Those (25) improvement projects were selected to treat the causes of loss factories and units which entered into the implementation of the program was the formation of working groups to this topic themes by workers and engineers ISPAT company and that as projects are implemented to determine the reasons for the loss and treatment under the supervision of the head of the focus improvement pillar each unit productivity and the supervisory committee the implementation of TPM. Table 5.3 shows seven improvement projects in TS-4 and TS-5.

These are some examples of what has been done:

1. Check was done to the first step of autonomous maintenance to (2) equipments in TS-5 and has passed the first step.
   Then check for the second step of autonomous maintenance to (8) equipment and (3) equipment have passed for the second step.
2. Continue to pursue the implementation of on-site equipment and typical equipment added.
3. Resume treatment of elements loss through focus improvement pillar by choosing (7) projects.
4. Continue in creating a work environment through the implementation of health and safety and the environment pillar areas.

5.4 Questionnaire results

To enhance the findings of this study from the interview questions, the researcher triangulated the data required through the most popular data collection method (questionnaire survey). The questionnaire survey is designed from five sections.

Plant		Focus improvement Projects (25)	Target	Selected Date	Target Date
TS-4 Bar Mill	1	To reduce roll consumption at the Bar Mill in the Roughing mill. TS4– KK-01/ BM01- Lin-2	Reduce 5% of Existing	20.08.2008	15.12.2008
	2	To reduce missing rolls due to guide failure in Intermediate Mill. TS4– KK-02/ BM-02- Lin-2	Reduce 50% of Existing	10.08.2008	01.12.2008
	3	To improve the yield from 96.50% to 96.75% in Bar Mill. TS4– KK-03/ BM-03- Lin-2	Improve To 96.75 %	10.09.2008	31.12.2008
	4	To Reduce time gap between Bellets At W.R.M Line-B TS4– KK-04/ W.R.M -01	Reduce 50% of Existing	01.12.2008	31.01.2009
TS-5 Section Mill	5	To Reduce cobble ratio in size I-BEAM 200 from 4.2% to 2.5% . TS5-KK-01/SL-01	Reduce From (4.2% To (2.5%)	20.10.2008	31.12.2008
	6	To Improve quality (ROM + ROS) defect TS5– KK-02/ SL-02	Improve From (80% To (84%)	20.08.2008	31.12.2008
	7	To Improve yield in size C80 * 45 * 6 from 80.2 (average 2007) to 83–84% TS5– KK-03/ SL-03	Improve From (2% To (3.3%)	20.08.2008	31.12.2008

TABLE 5.3: Focus improvement projects.

Section one is an introduction to explain the concept and the purpose of the questionnaire. Whereas, section two is about general information on the background of respondents which is known as demographic questions. They address the respondents' job, qualification, age, experience period and position in the organisation. Further, Section three is addressing the TPM activities within LISCO. This section consists of twenty statements incorporating the 5-point Likert scale. Moreover, section four is about the opinion regarding factors that affecting the success of TPM implementation. It consists of 60 statements which also incorporated the 5-point Likert scale. Finally, section five is addressing the evaluation and rank of the factors affecting the success of TPM implementation.

According to Hussey, Hussey, and Hussain (1997), it is often possible to allow participants to give more discriminating responses by providing them with some forms of rating scale, one of the more frequently used types of scale is the 'Likert Scale'.

The questionnaire was distributed through the TPM directorate committee. It was distributed to individuals who apply TPM on the Model Machine in the Longitudinal Rolling Plants, where it has two plants, namely, the Bar and Rod Mill(TS-4) and the Light and Medium Section Mill (TS-5). All Model Machines were chosen from each plant where TPM is applied to a number of Model Machine with the participation of a group of operators and maintenance personnel and engineers, as well as, the participation of members of occupational safety and R and D department. The number of the participants in each Model Machine are estimated between 8 to 10 persons depending on the machine size and complexity. Also, the questionnaires were distributed to all TPM Pillars' Chiefs, members and supervisors in the plant.

The responses were high from the unit TS-4, they were 50/80, which equals 63%, and the responses from unit TS-5 were good with the rate of 48/80, which equals 60%. Therefore, the total number of responses from both cases were 98 from 160 giving a return rate of nearly 62%. The data obtained in this study was analysed using Statistical Package for Social Sciences (SPSS). This program is a statistical software widely used in social studies and researches. The program is used to enter and save data for different

statistical analyzes, starting from the simple analysis such as tables of frequencies, and descriptive statistical indicators to advanced analysis, such as multivariate analysis and factors analysis.

5.4.1 Reliability and Validity Test

The reliability test is basically a tool that helps in stability and consistency within results, basically to develop the quality within empirical research. Basically, the aim for using this reliability test is to remove errors and biasses from the results of the study. According to Yin (2003), a method for achieving reliability is to make the operative steps as many as possible and perform research. Hence, this would require the proper documentation of the methods and process involved in the case study research.

For estimating the consistency of research Cronbach's alpha (a) model was used in reliability test. The extent to which the elements are homogenous and the extent to which they are associated with each other is represented by the values of alpha. The basic aim for doing these reliability and validity tests before briefing the actual survey results in the context of particular methods studied is to present the validity and reliability of the questionnaires. Cronbach's alpha reliability coefficient normally ranges between 0 and 1. However, there is actually no lower limit to the coefficient. The closer Cronbach's alpha coefficient to 1.0, the greater the internal consistency of the items in the scale (Fielding and Fielding, 1986).

The test was performed to examine the validity and credibility of each part of the questionnaire and how much they posses consistency. The values of alpha are considered as representatives of consistency. If the value of alpha is less than 60% then it is considered weak, on the other hand, if it is between 60% - 70%, then it is acceptable. Further, if it is between 70% - 80%, then it is considered good, and if it is above 80%, then it is considered excellent. A low value of alpha could be due to a low number of questions, poor interrelatedness between items or heterogeneous constructs. Table 5.4 provides a summary of the reliability analysis. Table 5.4 shows that the alpha value for TPM

No	Item	Number of statements	Alpha
1	TPM activities at LISCO	20	0.862
2	TPM factors	60	0.842
	Total	**80**	**1.704**

TABLE 5.4: Result of the reliability test

activities is 0.862, and the alpha value for TPM factors is 0.842. Both of these values are above 0.800. Therefore, the adopted scales in this study are considered reliable with the collected sample and were achieved from the pilot study accomplished by the author.

5.4.2 Respondents' profile (Unit(TS-4))

General characteristics of the sample in Unit(TS-4) is described hereinafter. The main purpose of this section is to describe the participants in this research who completed the questionnaire with respect to the following demographic variables: respondents qualification, respondents job, respondents experience, respondents origin, respondents age, and respondents occupation in TPM program.

(Nakajima, 1988) noted that it is important to give a description of the demographic characteristics of the research sample, even if the framework of the study does not test these variables.

5.4.2.1 Respondents Qualification

Table 5.5 below, shows the qualification distribution of the (TS4) respondents. The majority of the respondents are technicians and engineers, 56% and 40% respectively. The remaining 4% are employees. See Figure 5.1.

No	Qualification	Frequency	Percentage
1	Engineer	20	40
2	Technician	28	56
3	Employee	2	4
	Total	**50**	**100%**

TABLE 5.5: Respondents Qualifications.

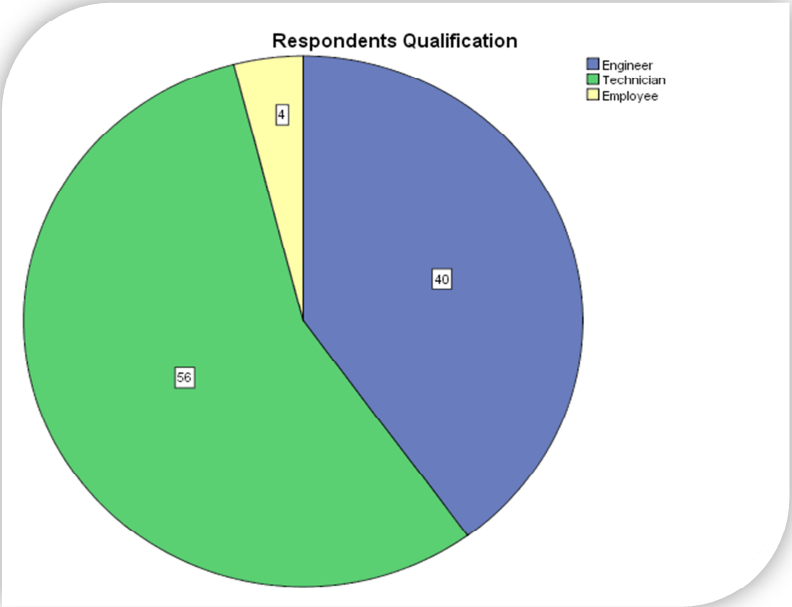

FIGURE 5.1: Respondents Qualifications.

5.4.2.2 Respondents Job

Table 5.6 shows the job distribution of the (TS4) respondents. The majority of the respondent are operators forming 42% of participants, whereas, the maintenance personnel reached 14% of the total, and 14% are operation engineers, while 14% were maintenance engineers. Also there are 2% management respondents and 14% others that included trainers and health and safety members. See Figure 5.2.

No	Job	Frequency	Percentage
1	Operator	21	42
2	Maintenance Personnel	7	14
3	Operation Engineer	7	14
4	Maintenance Engineer	7	14
5	Manager	1	2
6	Other	7	14
	Total	**50**	**100%**

TABLE 5.6: Respondents Job.

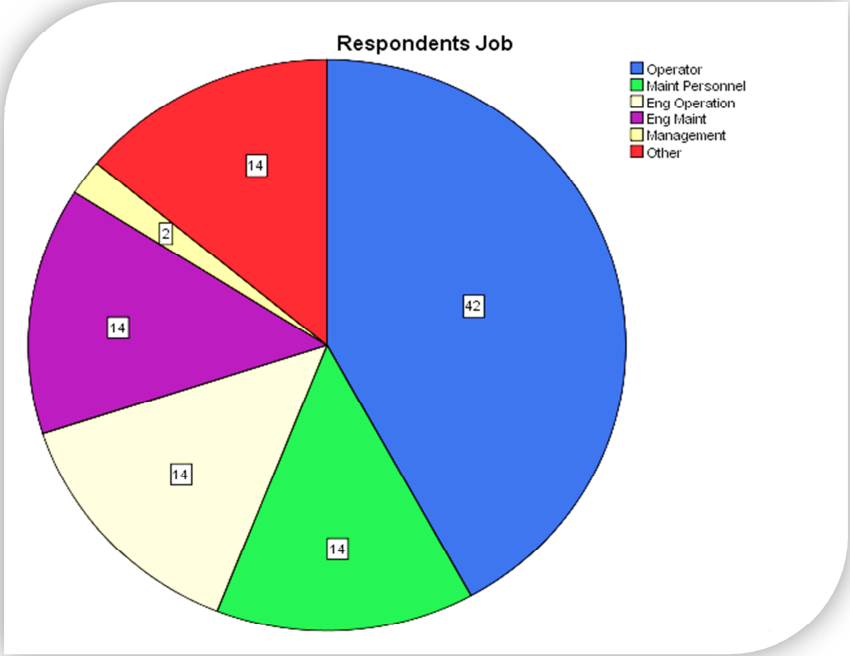

FIGURE 5.2: Respondents Job.

5.4.2.3 Respondents Experience

Table 5.7 shows the experience distribution of the (TS-4) respondents. Just the minority of the respondents summing to 4% have less than 3 years of experience. Whereas, 48% of the respondents have from 4 to 9 years of experience, and 34% of them have from 10

to 15 years of experience. However, 14% of the respondents have more than 16 years of experience. See Figure 5.3.

No	Years of Experience	Frequency	Percentage
1	<3	2	4
2	From 4 to 9	24	48
3	From 10 to 15	17	34
4	>16	7	14
	Total	**50**	**100%**

TABLE 5.7: Respondents Experience.

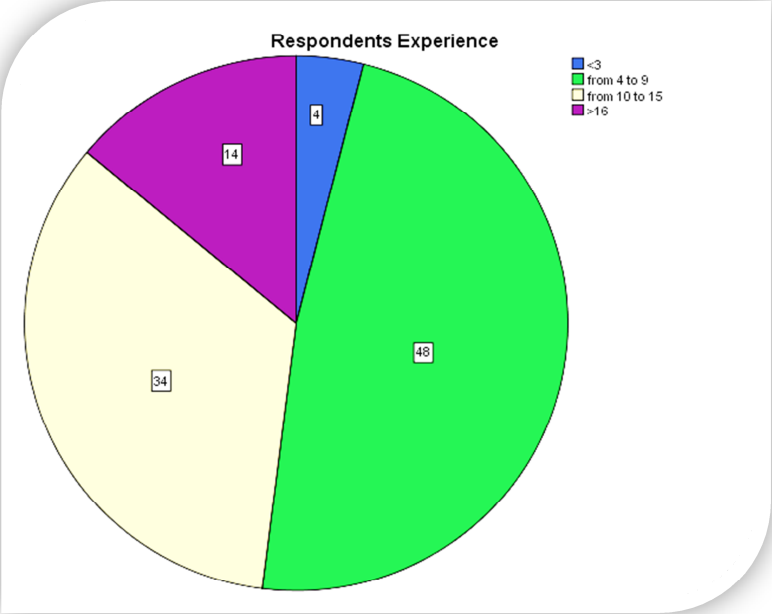

FIGURE 5.3: Respondents Experience.

5.4.2.4 Respondents Origin

Table 5.8 shows the origin distribution of the (TS-4) respondents. The majority of respondents (48 out of 50, representing 96% of the sample) were locals. The remaining 2 respondents (4% of the sample) were foreigners (Figure 5.4) which indicates that more local workers are represented in the sample than foreigners. this typifies the total population (350).

No	Origin	Frequency	Percentage
1	Local	48	96
2	Foreigner	2	4
	Total	**50**	**100%**

TABLE 5.8: Respondents Origin.

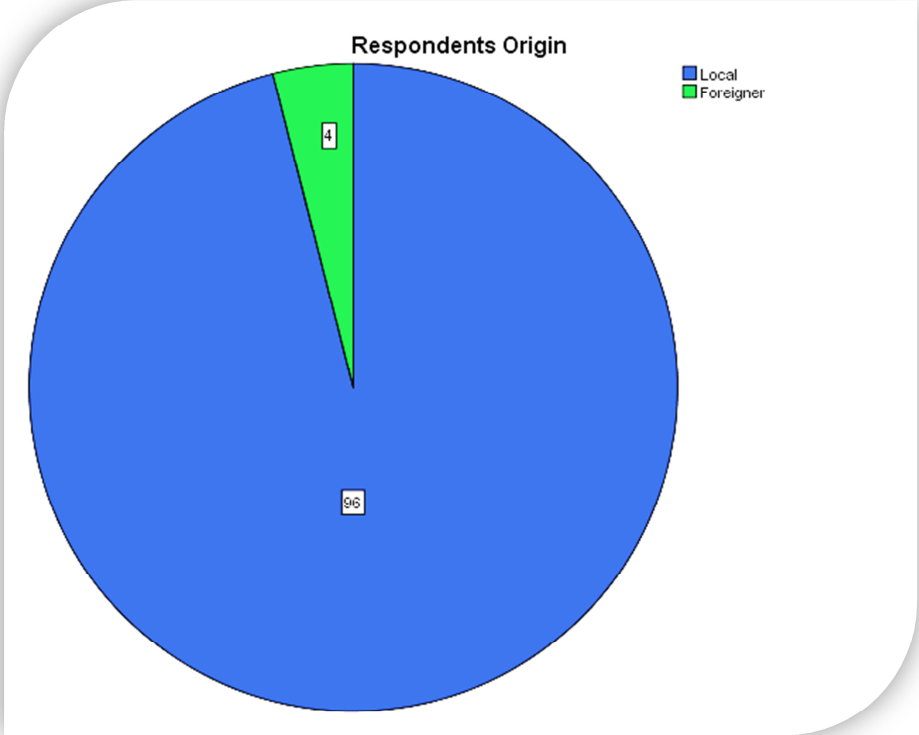

FIGURE 5.4: Respondents Origin.

5.4.2.5 Respondents Age

Table 5.9 shows the age distribution of the (TS-4) respondents. The highest percentage of respondents' age are people aged between 40 to 49 years, which represents 42% of the sample. This table also shows that the second highest percentage is for people aged between 30 to 39 years, which represents 40% of the sample. There are 16% of respondents who are aged over 50 years old, and the lowest percentage of respondents' age is 2% representing people aged between 20 to 29 years old. See Figure 5.5.

No	Age (years)	Frequency	Percentage
1	From 20 to 29	1	2
2	From 30 to 39	20	40
3	From 40 to 49	21	42
4	< 50	8	16
	Total	**50**	**100%**

TABLE 5.9: Respondents Age.

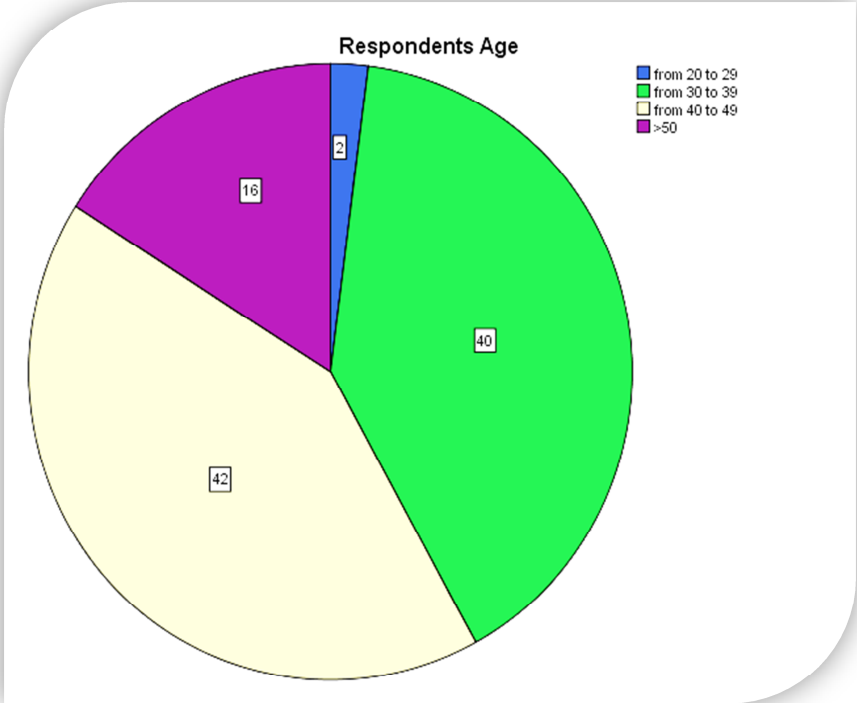

FIGURE 5.5: Respondents Age.

5.4.2.6 Respondents Occupation in TPM

Table 5.10 shows the occupational distribution of the (TS4) respondents. As shown in this table, it is so clear that 44% of respondents are working as autonomous maintenance members. Whereas, 20% of respondent are members of planned maintenance team, and 14% are members of focused improvement team. The education and training, and SHE have the lowest percentage which is 6% of respondents. The TPM directorate committee has 10% of the respondents. See Figure 5.6.

No	Occupation	Frequency	Percentage
1	JH (Autonomous Maintenance)	22	44
2	PM (Planned Maintenance)	10	20
3	KK (Focus Improvement)	7	14
4	SHE (Safety, Health and Environment)	3	6
5	ET (Education and Training)	3	6
6	TPM Dir. Comm. (TPM directorate committee)	5	10
	Total	**50**	**100%**

TABLE 5.10: Respondents Occupation in TPM.

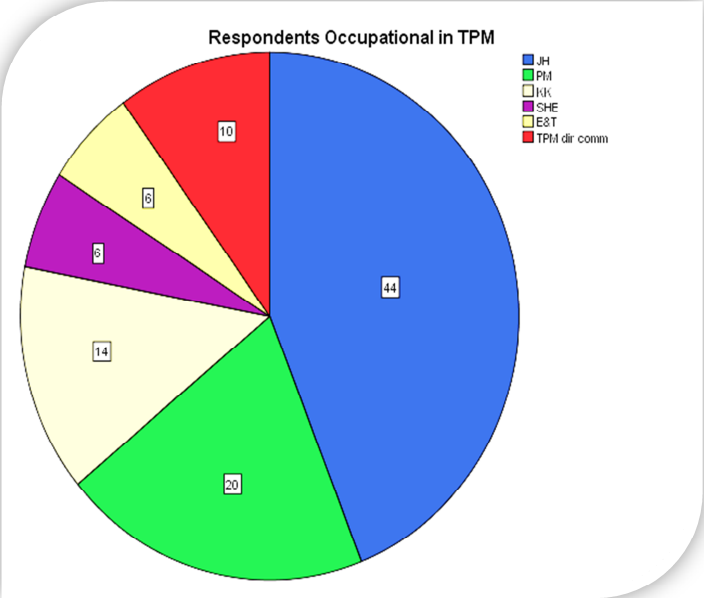

FIGURE 5.6: Respondents Occupation in TPM.

5.4.3 TPM activities and monitoring receptivity, Unit(TS- 4)

Table 5.11 illustrates the measures of TPM activities and monitoring receptivity of the participants. Twenty statements on a 5-points scale was used to identify to what extent respondents have agreed or disagreed with the given statements.

No	Item Description	Percentage					Mean	Std. D
		SD	D	N	A	SA		
1	Dealt seriously with focus improvement projects.	18	44	14	12	12	2.560	1.264
2	TPM reduced product wastes.	2	14	16	58	10	3.600	0.9258
3	Autonomous maintenance is stepped perfectly.	0	26	24	40	10	3.340	0.9811
4	TPM built more “ownership” for equipment.	0	18	26	50	6	3.440	0.8600
5	No more breakdown maintenance.	16	36	20	26	2	2.6200	1.104
6	TPM built teamwork spirit between operators and maintenance personnel.	0	4	26	60	10	3.7600	0.6861
7	There is improvement in production quality due to TPM.	2	14	22	54	8	3.520	0.9081
8	Loss of assistant material is becoming less.	2	12	16	54	16	3.700	0.9529

9	I received the proper training to do TPM tasks.	0	14	26	50	10	3.560	0.8609
10	Skills of maintenance personnel and operators are increased.	0	16	24	44	16	3.600	0.9472
11	TPM makes it easier to get the job done.	0	10	18	56	16	3.780	0.8400
12	TPM is helping to improve equipment.	0	10	24	54	12	3.680	0.8191
13	Your workplace is becoming safer and more comfortable.	0	8	22	58	12	3.7400	0.7774
14	Safety was stressed during training sessions.	2	6	26	44	22	3.7800	0.9320
15	There are supervision supports TPM.	4	14	22	42	18	3.5600	1.072
16	You are satisfied about the current performance of TPM directorate and steering committees.	4	14	24	46	12	3.480	1.014
17	TPM should be expanded to other areas in my vision.	6	14	14	54	12	3.5200	1.073
18	Other people in my area support TPM.	0	18	22	56	4	3.4600	0.838
19	I feel confident doing TPM tasks.	0	10	22	58	10	3.6800	0.7931
20	I liked the way TPM was implemented in my area.	0	10	24	58	8	3.6400	0.7764

TABLE 5.11: TPM Activities and monitoring receptivity, Unit(TS- 4).

The main indications that can be generated from the questionnaire results (first part: TPM activities and monitoring receptivity) are:

Relating to the focus improvement projects, 62% of the respondents (18% SD and 44% D) disagreed that there was a serious deal with the focus improvement projects, and 68% of respondents (10% SA and 58% A) agreed that TPM reduced product wastes. Only, 50% of the respondents (10% SA and 40% A) agreed that autonomous maintenance was stepped perfectly, and 56% of the respondents (6% SA and 50% A) agreed that TPM built more "ownership" between the equipment and operators. Nearly, 52% of respondents disagreed with the statement that said "no more breakdown maintenance". High percentage of respondents 70% (60% A and 10% SA) agreed that "TPM built teamwork spirit between operators and maintenance personnel". About 62% of respondents (8% SA and 54% A) indicated that there was an improvement in the production quality due to TPM. About 70% of respondents (60% SA and 10% A) showed that the loss of assistant material in unit (TS-4) is becoming less. Whereas, 60% of respondents (10%SA and 50%A) believed that they received proper training to do TPM tasks. Skills of maintenance personnel and operators were increased, which was confirmed by 60% of respondents (16% SA and 44% A).72% of respondents (16% SA and 56%) agreed with the statement "TPM makes it easier to get the job done", and 66% of respondents (12% SA and 54%) believed that TPM is helping to improve equipment. On the other hand, 70% of respondents (12% SA and 58% A) confirmed that workplace is becoming safer and more comfortable. Regarding the safety, 66% of respondents (22% SA and 44%A) agreed that "Safety was stressed during training sessions". With regard to the supervision, only 60% of respondents (18% SA and 42%A) agreed that there was supervision that supports TPM. Very low percentage of 58% of respondents who were satisfied about the current performance of TPM directorate and steering committees. However, 66% of respondents (12% SA and 54%A) agreed that TPM should be expanded to other areas, and just 60% of respondents confirmed that the other people in their area support TPM. In relation to the feeling about TPM, 68% of respondents feel confident about doing TPM tasks. About 66% of respondents like the way TPM was implemented in their area.

5.4.4 TPM Factors, Unit(TS-4)

5.4.4.1 Top management commitment

The top management commitment was measured through three questions. Respondents were asked to rate their extent of agreement or disagreement with the given statement concerning their top managers who dealt with TPM on a five-point Likert scale.

Table 5.12 includes three statements that were grouped to examine the attitude of the respondents regarding 'Top Management Commitment' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Top management of organization has a clear understanding of the concept of TPM.	14	42	14	26	4	2.64	1.138
Q2	There is a top management support to TPM.	10	56	20	14	0	2.380	0.854
Q3	Top management is willing to adopt the TPM concept.	0	6	32	50	12	3.680	0.767
F1	Top Management Commitment.							

TABLE 5.12: Top management commitment, Unit(TS-4).

Table 5.12 illustrates the extent of degree of top management commitment in TPM adoption in LISCO (TS-4). The first statement "Top management of organization has a clear understanding of the concept of TPM ", (56%) of the respondents (14% SD and 42% D) disagreed with the statement with mean score of (2.64) and standard deviation of (1.138). In the second statement "There is a top management support to TPM", (66%) of the respondents (10% SD and 56% D) disagreed with this statement with mean of (2.380) and standard deviation of (0.854). The third statement "Top management is willing to adopt the TPM concept" had a (62%) of the respondents (12% SA 50% A) that agreed with this statement with mean of (3.680) and standard deviation of (0.767).

5.4.4.2 Employee involvement

Table 5.13 illustrates the statements, that were grouped to measure the attitude of the respondents regarding the 'Employee involvement' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is employee involvement in management decisions.	10	42	16	30	2	2.720	1.069
Q2	There is awareness of TPM among employees in the organization.	0	16	22	44	18	3.640	0.963
Q3	TPM objectives are clearly identified to employees.	2	8	26	52	12	3.640	0.875
F2	Employee involvement.							

TABLE 5.13: Employee involvement, Unit(TS-4).

Table 5.13 shows that about (52%) of respondents (10%SD and 42%D) were disagreed with first statement "There is employee involvement in management decisions", but there were (62%) of respondents agree with the second statement "There is awareness of TPM through employees in the organization". In the third statement "TPM objectives are clearly identified to employees", where (64%) of the respondents (52% A and 12% SA) see that TPM objective are clearly identified to them.

5.4.4.3 Motivation, Rewards and Recognition

The scale of statement degree regarding this factor is displayed in Table 5.14, and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Employees are rewarded for the additional workload.	12	18	14	46	10	3.240	1.221
Q2	The organization has a motivation and reward system.	6	28	16	40	10	3.040	1.029
Q3	There is a general sense of high morale in the organization.	12	46	14	22	6	2.640	1.138
F3	Motivation, Rewards and Recognition.							

TABLE 5.14: Motivation, Rewards and Recognition, Unit(TS-4).

Table 5.14 shows that 56% of respondents (10%SA and 46%A) were agreed with first statement "Employees are rewarded for the additional workload" , and there were 50% of respondents (10% SA and 40% A) agree with the second statement "The organization has a motivation and reward system ". In the third statement "There is a general sense of high morale in the organization", where 58% of the respondents (12% SD and 46% D) have disagreed with the statement.

5.4.4.4 Time allocation for implementation

Table 5.15 includes three statements that were grouped to examine the attitudes of the respondents regarding "Time allocation for implementation" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Sufficient time for implementation.	8	22	10	50	10	3.320	1.168
Q2	There is a clear understanding of time management.	16	44	36	2	2	2.300	0.839
Q3	Sufficient time for auditing TPM.	6	18	22	44	10	3.340	1.080
F4	Time allocation for implementation.							

TABLE 5.15: Motivation, Rewards and Recognition, Unit(TS-4).

Table 5.15 shows that 60% of respondents (10% SA and 50% A) have agreed with the first statement "there was sufficient time to implementation", and there were 60% of respondents (16% SD and 44% D) that disagreed with the statement "There is a clear understanding of time management". In the last statement in this factor, 54% of respondents (10% SA and 44% A) agreed that there was sufficient time to auditing TPM.

5.4.4.5 Resource allocation for implementation

Table 5.16 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Resource allocation for implementation' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is availability of sufficient resources.	14	50	14	20	2	2.460	1.034
Q2	Effective practice of resource and material requirement planning system (MRP).	18	36	20	16	10	2.640	1.241
Q3	There is availability of main resources in the form of method analysis tools.	22	46	22	10	0	2.200	0.903
F5	Resource allocation for implementation.							

TABLE 5.16: Resource allocation for implementation, Unit(TS-4).

Table 5.16 shows that 54% of respondents (14%SD and 50% D) disagreed about "There is availability of sufficient resources", and 54% of respondents disagreed that there was effective practice of (MRP) in the organisation. Only, 68% of respondents confirmed that there is no availability of main resource in the form of method analysis tools.

5.4.4.6 Alignment to company mission

Table 5.17 includes three statements that were grouped to examine the attitudes of the respondents regarding the "Alignment to company mission" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The company business strategy align to TPM philosophy and principles.	4	10	24	48	14	3.580	0.991
Q2	There is strategic vision for the future about TPM in the organization.	0	10	22	54	14	3.720	0.833
Q3	Company policy committed TPM to meet customer requirements and continuous improvement.	8	16	18	48	10	3.360	1.120
F6	Alignment to company mission.							

TABLE 5.17: Alignment to company mission, Unit(TS-4).

Table 5.17 shows that 62% of respondents (14% SA and 48% A) were agreed that the company business strategy align to TPM philosophy and principles, and about 68% of them believed that there is strategic vision for the future about TPM in the organisation.

58% of respondents were agreed with the statement "Company policy is committed TPM to meet customer requirements and continuous improvement".

5.4.4.7 Performance measurement of TPM

The scale of statement degree regarding this factor is displayed in Table 5.18 and it shows the percentage of agreement and this agreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	TPM performance is noticeable to all participants.	20	50	12	16	2	2.300	1.035
Q2	There is TPM performance measurement.	38	32	16	10	4	2.100	1.147
Q3	TPM results give good impact to the participants.	2	2	20	46	30	4.00	0.880
F7	Performance measurement of TPM.							

TABLE 5.18: Performance measurement of TPM, Unit(TS-4).

Table 5.18 illustrates that 70% (20% SD and 50% D) disagreed that TPM performance is noticeable to all participants, and 70% of respondents(38% SD 32%D) believed that there was not TPM performance measurement at the plant. The majority of respondents (76%) think that TPM results gave good impact to the participants.

5.4.4.8 Implementation plan and process

Table 5.19 illustrates the statements that were grouped to measure the attitude of the respondents regarding the 'Implementation plan and process' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is compliance with the master plan for TPM implementation.	10	52	22	14	2	2.460	0.930
Q2	There is an effective practice of TPM support tools (e.g. OPL, visual control system, Why-Why analysis, etc).	10	50	26	12	2	2.460	0.908
Q3	The plan of TPM implementation does not conflict with the general production plan.	2	12	26	48	12	3.560	0.929
F8	Implementation plan and process.							

TABLE 5.19: Implementation plan and process, Unit(TS-4).

Table 5.19 shows that 62% of respondents (10% SD and 52% D) disagreed with the statement "There is compliance with the master plan for TPM implementation", and only 60% of respondents disagreed that there is effective practice of TPM support tools at the plants. Regarding the last statement in this factor, about 60% of respondents agreed that the plan of TPM implementation does not conflict with the general production plan.

5.4.4.9 Effective Communication

Table 5.20 includes three statements that were grouped to examine the attitudes of the respondents regarding "Effective Communication" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Communication between departments is effective.	16	52	12	16	4	2.400	1.069
Q2	There is a good communication from senior management level to employees.	12	46	26	16	0	2.460	0.908
Q3	There is an effective contact system between the company and customers.	6	16	22	52	4	3.320	0.998
F9	Effective Communication.							

TABLE 5.20: Effective Communication, Unit(TS-4).

Table 5.20 shows 68% of respondents(16% SD and 52% D) believe that the communication between departments is not effective. Only, 58% of respondents said that there isn't a good communication from senior management level to employees. Very low percentage of 56% (4% SA and 52% A) were agreed that "There is an effective contact system between the company and customers".

5.4.4.10 Integration with other manufacturing management programs

Table 5.21 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Integration with other manufacturing management programs' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Participants have knowledge about any other manufacturing programs.	10	52	24	12	2	2.440	0.907
Q2	The integration with other manufacturing programs has positive impact on successful implementation of TPM.	0	8	24	54	14	3.740	0.803
Q3	There is a link between TPM and other manufacturing programs.	2	8	32	46	12	3.580	0.882
F10	Integration with other manufacturing management programs.							

TABLE 5.21: Integration with other manufacturing management programs, Unit(TS-4).

Table 5.21 shows that 62% of respondents (10% SD and 52% D) disagreed with the statement "Participants have knowledge about any other manufacturing programs", and 68% agreed that The integration with other manufacturing programs has positive impact on successful implementation of TPM. In the last statement in this factor, only 58% of respondent believe that there is a link between TPM and other manufacturing program.

5.4.4.11 Cooperation

The scale of statement degree regarding this factor is displayed in Table 5.22 and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is cross-functional cooperation between departments.	2	18	20	52	8	3.460	0.952
Q2	There is cooperation between the members of small group activity.	4	22	24	38	12	3.320	1.077
Q3	There is a good cooperation from the company partners.	10	48	18	18	6	2.620	1.085
F11	Cooperation.							

TABLE 5.22: Cooperation, Unit(TS-4).

Table 5.22 shows that 60% of respondents agreed with the statement that said "There is cross-functional cooperation between departments", and only 60% (12% SA and 38%A) were agreed that "There is cooperation between the members of Small Group Activity". About 58% of respondents disagreed with the statement that said "There is a good cooperation from the company partners".

5.4.4.12 Coordination and leadership

Table 5.23 includes three statements that were grouped to examine the attitudes of the respondents regarding "Coordination and leadership" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is an effective and expert leadership and coordinators.	2	14	20	48	16	3.620	0.987
Q2	The promotion of managers in departments within the company is based on qualifications.	10	52	16	20	2	2.520	0.994
Q3	There are full-time coordinators for monitoring TPM.	0	10	22	46	22	3.800	0.903
F12	Coordination and leadership.							

TABLE 5.23: Coordination and leadership, Unit(TS-4).

Table 5.23 shows that 64% of respondents (16% SA and 48% A) agreed that "There was an effective and expert leadership and coordinators", about "The promotion of managers in departments within the company is based on qualifications", 62% of respondents were agreed with this statement. Moreover, 68% of respondents (22% SA and 46% A) agreed that there were full-time coordinators for monitoring TPM.

5.4.4.13 Cultural change, knowledge and beliefs and acceptance

Table 5.24 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Cultural change, knowledge, beliefs and acceptance' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The receptivity to change of people towards TPM is acceptable.	2	16	20	42	20	3.620	1.047
Q2	Implementation of TPM program does not threaten your job security and increases the work load.	8	42	10	26	14	2.960	1.261
Q3	A bureaucratic culture is not prevalent in the organization.	30	42	18	8	2	2.960	1.261
F13	Cultural change, knowledge, beliefs and acceptance.							

TABLE 5.24: Cultural change, knowledge, beliefs and acceptance, Unit(TS-4).

Table 5.24 shows that 62% of respondents agreed with this statement. Only, 50% of respondent believe that implementation of TPM program does not threaten your job security and increases the work load. About a bureaucratic culture, 76% of respondent see that a bureaucratic culture is prevalent in the organization.

5.4.4.14 Availability of information and documentation

The scale of statement degree regarding this factor is displayed in Table 5.25 and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The organization has clear rules for the use of handling and updating of the information.	2	10	26	48	14	3.620	0.923
Q2	There is an effective practice of documentation system in the organization.	10	44	16	24	6	2.720	1.125
Q3	The availability of information at the right time and right place.	14	42	20	22	2	2.560	1.052
F14	Availability of information and Documentation.							

TABLE 5.25: Availability of information and Documentation, Unit(TS-4).

Table 5.25 shows that 62% of respondents (14% SA and 48% A) believe that "The organization has clear rules for the use of handling and updating of the information", and 54% disagreed that "There is effective practice of documentation system in the organization". In the last statement of this factor 56% of respondents were disagreed with this statement.

5.4.4.15 Empowerment

Table 5.26 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Empowerment' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Employees have been held more responsibility in their working environment.	12	18	8	48	14	3.340	1.271
Q2	Participants are empowered to make change in their work whilst performing their duties.	12	18	20	44	6	3.140	1.160
Q3	Giving power must be as much as holding responsibility.	4	8	22	44	22	3.720	1.030
F15	Empowerment.							

TABLE 5.26: Empowerment, Unit(TS-4).

Table 5.26 shows that 62% of respondents (14% SA and 48% A) were agreed that "Employees have been held more responsibility in their working environment", and only 50% of respondents were agreed that "Participants are empowered to make change in their work whilst performing their duties". About 66% of respondents believe that giving power must be as much as holding responsibility.

5.4.4.16 Formation of TPM office and Steering committees

Table 5.27 includes three statements that were grouped to examine the attitudes of the respondents regarding "Formation of TPM office and Steering Committees" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Proper organizational structure has been developed to implement TPM.	18	44	16	22	0	2.420	1.031
Q2	An experienced directorate and steering committees.	16	44	12	24	4	2.560	1.145
Q3	There is interest of the committees about regular meetings.	20	40	16	24	0	2.440	1.072
F16	Formation of TPM office and Steering committees.							

TABLE 5.27: Formation of TPM office and Steering committees, Unit(TS-4).

Table 5.27 shows that 62% of respondents (18% SD and %44 D) disagreed with the statement "Proper organizational structure has been developed to implement TPM", and 60% agreed that there were an experienced directorate and steering committees. Moreover, 60% of respondents said "There is interest of the Committees about regular meetings".

5.4.4.17 Existing maintenance system, equipment and workplace conditions

The scale of statement degree regarding this factor is displayed in Table 5.28 and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The condition of the equipment is appropriate to apply TPM.	8	26	12	46	8	3.200	1.160
Q2	The condition of the workplace is appropriate to apply TPM.	8	42	22	22	6	2.760	1.079
Q3	Sufficient technology and the existing maintenance system is good.	8	56	14	18	4	2.540	1.014
F17	Existing maintenance system, equipment and workplace conditions.							

TABLE 5.28: Existing maintenance system, equipment and workplace conditions, Unit(TS-4).

Table 5.28 shows that 54% of respondents (8% SA and 46% A) agreed with the statement that said "The condition of the equipment is appropriate to apply TPM", and only 50% believe that the condition of the workplace is appropriate to apply TPM. Moreover, 64% of respondents (8% SD and 56% D) disagreed with the statement that said "Sufficient technology and the existing maintenance system is good".

5.4.4.18 Training and education

Table 5.29 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Training & Education' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Sufficient quality training and education.	6	54	20	14	6	2.600	1.010
Q2	The organization trains its employees with a clear purpose.	10	42	22	22	4	2.680	1.058
Q3	Training targets in the organization are generally not achieved.	4	18	22	52	4	3.340	0.960
F18	Training and education.							

TABLE 5.29: Training and education, Unit(TS-4).

Table 5.29 shows that 60% of respondents (6% SD and 54% D) disagreed with the statement "sufficient quality training and education", and also 52% of them disagreed that "the organization trains its employees with a clear purpose", 56% of respondents (4% SA and 52% A) agreed that "Training targets in the organization are generally not achieved".

5.4.4.19 Union participation and acceptance

Table 5.30 includes three statements that were grouped to examine the attitudes of the respondents regarding the 'Union participation and acceptance' factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The trade union has a strong impact in your company.	38	32	18	10	2	2.060	1.076
Q2	The acceptance of the union can ensure TPM success.	6	36	36	16	6	2.800	0.989
Q3	The Union cares about the employee.	18	40	30	10	2	2.380	.966
F19	Union participation and acceptance.							

TABLE 5.30: Union participation and acceptance, Unit(TS-4).

Table 5.30 shows that 70% of respondents (38% SD and 32% D) disagreed with the statement "The trade union has a strong impact in your company", and very low percentage of respondents 42% disagreed that "The acceptance of the union can ensure TPM success". About 58% (18% SD and 40% D) disagreed with the statement that said "The Union cares about the employee".

5.4.4.20 Pilot project and gradual implementation on model machines

The scale of statement degree regarding this factor is displayed in Table 5.31 and it shows the percentage of agreement and this agreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The pilot project good results give confidence to the participants.	0	8	16	42	34	4.020	0.914
Q2	Pilot implementation can save time and effort.	0	6	18	48	28	3.980	0.844
Q3	Gradual implementation on model machines can be successful.	0	4	16	46	34	4.100	0.814
F20	Pilot project and gradual implementation on model machines.							

TABLE 5.31: Pilot project and gradual implementation on model machines, Unit(TS-4).

Table 5.31 shows that 76% of respondents (34% SA and 42% A) agreed that the good result from the pilot project gives confidence to participants. Also 76% of them believe that "Pilot implementation can save time and effort". Also, 80% of respondents (34% SA and 46% A) agreed that "Gradual implementation on model machines can be successful".

5.4.5 Evaluating the factors affecting TPM implementation (Unit(TS-4))

In reply to the question 'Please specify how important do you think the following factors to implement TPM successfully in your company?', the results are illustrated below in Table 5.32 showing the ranking of these factors in Unit(TS-4).

No	Factor	Percentage					Mean	Std. D	Rank
		SD	D	N	A	SA			
1	Top management commitment.	0	0	2.1	14.6	83.3	4.812	0.445	1
2	Employee involvement.	2.1	0	4.2	43.8	50	4.395	0.764	3
3	Motivation, rewards and recognition.	0	4.2	12.5	41.7	41.7	4.208	0.824	6
4	Time allocation for implementation.	0	6.3	18.8	45.8	29.2	3.979	0.862	13
5	Resource allocation for implementation.	0	0	25	41.7	33.3	4.083	0.767	8
6	Alignment to company mission.	0	6.3	27.1	45.8	20.8	3.812	0.841	17
7	Performance measurement of TPM.	0	0	18.8	39.6	41.7	4.229	0.750	5
8	Implementation plan and process.	0	2.1	20.8	45.8	31.3	4.062	0.782	9
9	Effective communication.	0	6.3	25	47.9	20.8	3.833	0.833	16
10	Integration with other manufacturing management programs.	0	14.6	22.9	50	12.5	3.604	0.892	19
11	Cooperation.	0	6.3	16.7	50	27.1	3.979	0.837	12
12	Coordination and leadership.	0	2.1	18.8	54.2	25	4.020	0.729	10
13	Cultural change, beliefs and acceptance.	0	2.1	27.1	41.7	29.2	3.979	0.811	11
14	Availability of information and documentation.	0	4.2	27.1	45.8	22.9	3.875	0.815	14
15	Empowerment.	0	2.1	27.1	54.2	16.7	3.854	0.714	15
16	Formation of TPM office and Steering committees.	0	6.3	39.6	29.2	25	3.729	0.916	18
17	Existing maintenance system, equipment & workplace conditions.	0	0	22.9	43.8	33.3	4.104	0.750	7
18	Training & education.	0	2.1	4.2	41.7	52.1	4.437	0.681	2
19	Union participation & acceptance.	6.3	16.7	39.6	31.3	6.3	3.145	0.989	20
20	Pilot project and gradual implementation on model machines.	0	4.2	14.6	31.3	50	4.270	0.868	4

TABLE 5.32: Evaluation of factors in Unit(TS- 4).

5.4.6 Respondents' profile (Unit(TS-5))

Similarly, the general characteristics of the sample in Unit(TS-5) is described hereinafter. The main purpose of this section is to describe the participants of this unit in this research who completed the questionnaire with respect to the following demographic variables: respondents qualification, respondents job, respondents experience, respondents origin, respondents age, and respondents occupation in TPM program.

5.4.6.1 Respondents Qualification

Table 5.33 below, shows the qualification distribution of the (TS-5) respondents. The majority of the respondents are technicians and engineers, 64.5% and 29% respectively. The remaining 6.2% are employees. See Figure 5.7.

No	Qualification	Frequency	Percentage
1	Engineer	14	29.1
2	Technician	31	64.5
3	Employee	3	6.25
	Total	**48**	**100%**

TABLE 5.33: Respondents Qualifications (Unit(TS-5)).

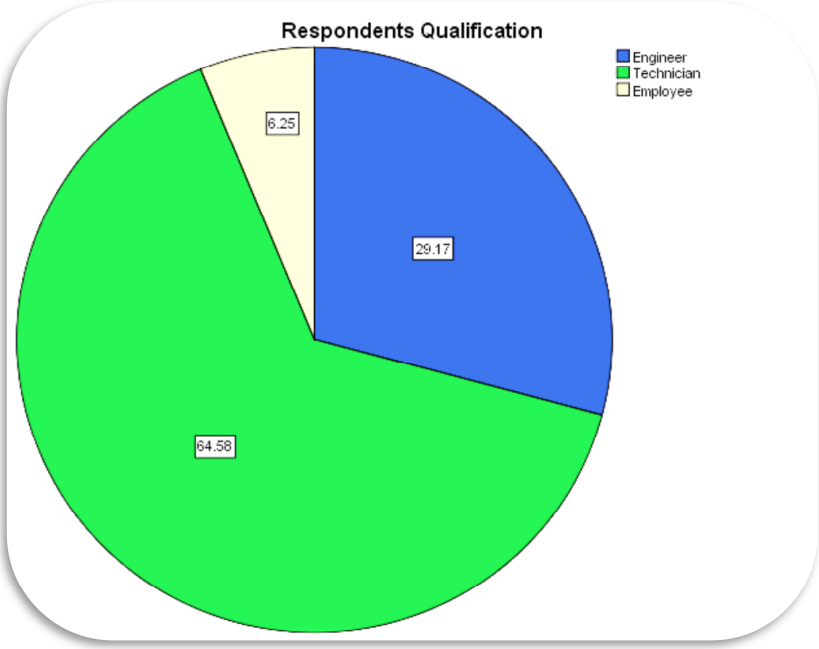

FIGURE 5.7: Respondents Qualifications (Unit(TS-5)).

5.4.6.2 Respondents Job

Table 5.34 shows the job distribution of the (TS-5) respondents. The majority of the respondent are operators forming 45.8% of participants, whereas, the maintenance personnel reached 16.6% of the total, and 12.5% are operation engineers, while 10.4% were maintenance engineers. Also there are 2.1% management respondents and 12.5% others that included trainers and health and safety members. See Figure 5.8.

No	Job	Frequency	Percentage
1	Operator	22	45.8
2	Maintenance Personnel	8	16.6
3	Operation Engineer	6	12.5
4	Maintenance Engineer	5	10.4
5	Manager	1	2.1
6	Other	6	12.5
	Total	**48**	**100%**

TABLE 5.34: Respondents Job (Unit(TS-5)).

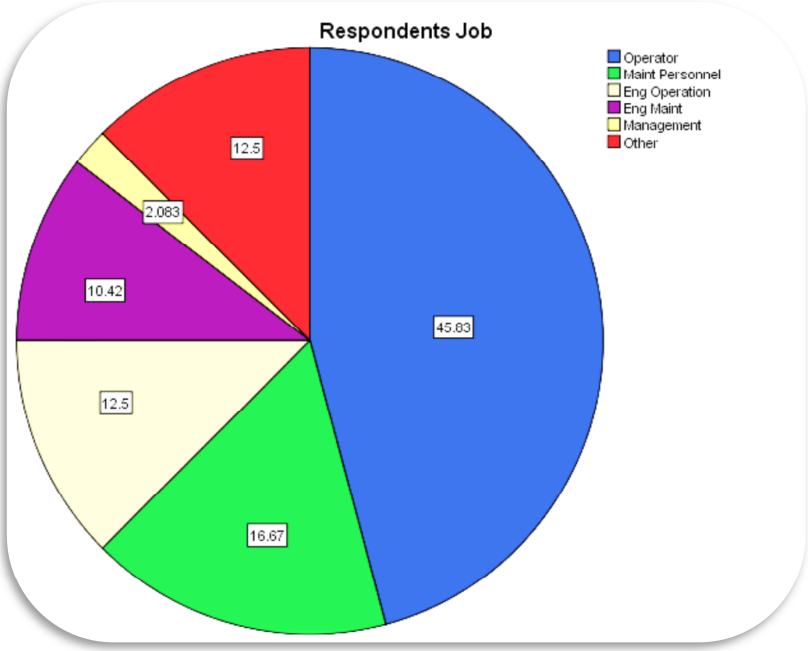

FIGURE 5.8: Respondents Job (Unit(TS-5)).

5.4.6.3 Respondents Experience

Table 5.35 shows the experience distribution of the (TS-5) respondents. Just the minority of the respondents summing to 8.3% have less than 3 years of experience. Whereas, 54.2% of the respondents have from 4 to 9 years of experience, and 25% of them have from 10 to 15 years of experience. However, 12.5% of the respondents have more than 16 years of experience. See Figure 5.9.

No	Years of Experience	Frequency	Percentage
1	<3	4	8.3
2	From 4 to 9	26	54.2
3	From 10 to 15	12	25
4	>16	6	12.5
	Total	**48**	**100%**

TABLE 5.35: Respondents Experience (Unit(TS-5)).

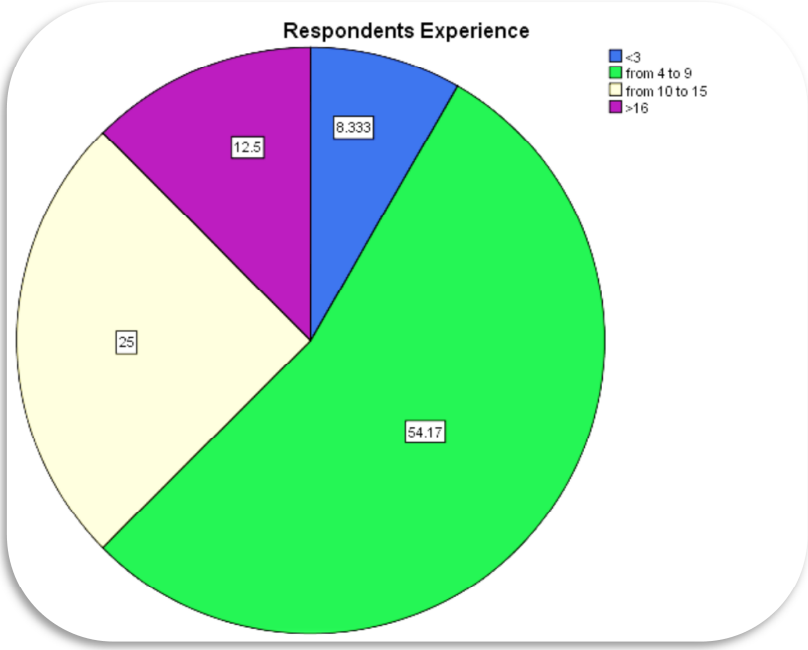

FIGURE 5.9: Respondents Experience (Unit(TS-5)).

5.4.6.4 Respondents Origin

Table 5.36 shows the origin distribution of the (TS-5) respondents. The majority of respondents (48 out of 50, representing 95.8% of the sample) were locals. The remaining 2 respondents (4.2% of the sample) were foreigners (Figure 5.10) which indicates that more local workers are represented in the sample than foreigners.

No	Origin	Frequency	Percentage
1	Local	46	95.8
2	Foreigner	2	4.2
	Total	**48**	**100%**

TABLE 5.36: Respondents Origin (Unit(TS-5)).

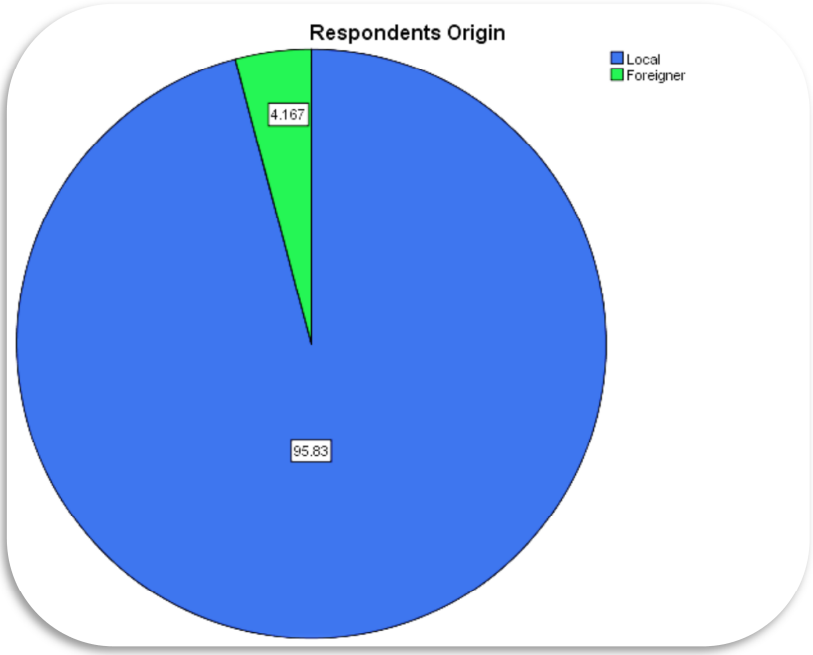

FIGURE 5.10: Respondents Origin (Unit(TS-5)).

5.4.6.5 Respondents Age

Table 5.37 shows the age distribution of the (TS-5) respondents. The highest percentage of respondents' age are people aged between 40 to 49 years, which represents 45.8% of the sample. This table also shows that the second highest percentage is for people aged between 30 to 39 years, which represents 35.4% of the sample. There are 12.5% of respondents who are aged over 50 years old, and the lowest percentage of respondents' age is 6.3% representing people aged between 20 to 29 years old. See Figure 5.11.

No	Age (years)	Frequency	Percentage
1	From 20 to 29	3	6.3
2	From 30 to 39	17	35.4
3	From 40 to 49	22	45.8
4	< 50	6	12.5
	Total	**48**	**100%**

TABLE 5.37: Respondents Age (Unit(TS-5)).

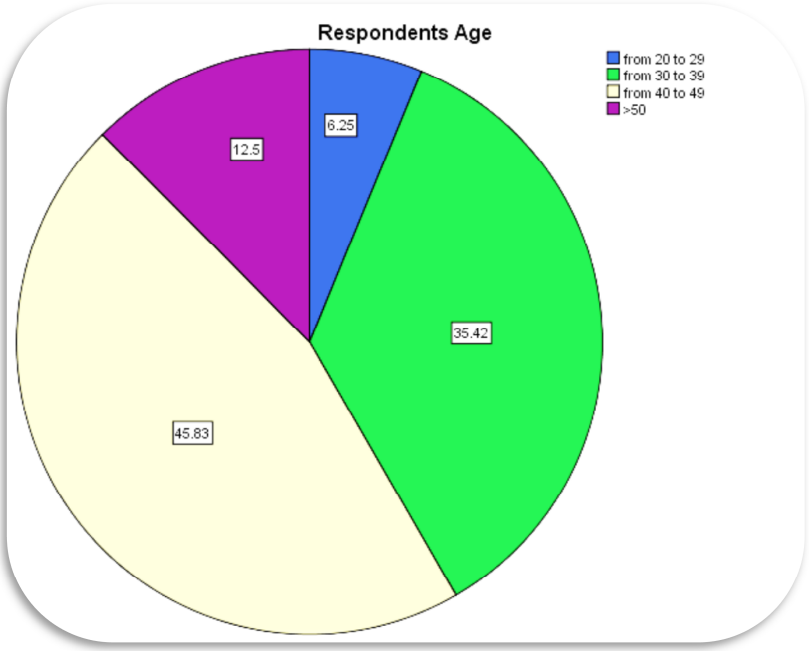

FIGURE 5.11: Respondents Age. (Unit(TS-5))

5.4.6.6 Respondents Occupation in TPM

Table 5.38 shows the occupational distribution of the (TS-5) respondents. As shown in this table, it is clear that 45.8% of respondents are working as autonomous maintenance members. Whereas, 22.9% of respondent are members of planned maintenance team, and 12.5% are members of focused improvement team. The education and training, and SHE have the lowest percentage which is 6.3% of respondents. The TPM directorate committee has 6.3% of the respondents. See Figure 5.12.

No	Occupation	Frequency	Percentage
1	JH (Autonomous Maintenance)	25	45.8
2	PM (Planned Maintenance)	8	22.9
3	KK (Focus Improvement)	6	12.5
4	SHE (Safety, Health and Environment)	3	6.3
5	ET (Education and Training)	3	6.3
6	TPM Dir. Comm. (TPM directorate committee)	3	6.3
	Total	**48**	**100%**

TABLE 5.38: Respondents Occupation in TPM (Unit(TS-5)).

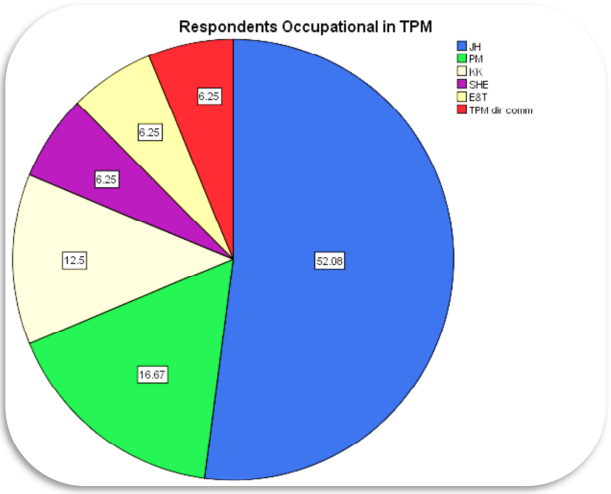

FIGURE 5.12: Respondents Occupation in TPM (Unit(TS-5)).

5.4.7 TPM activities and monitoring receptivity, Unit(TS-5)

Table 5.39 illustrates the measures of TPM activities and monitoring receptivity of the participants. Twenty statements on a 5-points scale was used to identify to what extent respondents have agreed or disagreed with the given statements.

No	Item Description	Percentage					Mean	Std. D
		SD	D	N	A	SA		
1	Dealt seriously with focus improvement projects.	8.3	20.8	14.6	35.4	20.8	3.3953	1.2671
2	TPM reduced product wastes.	2.1	8.3	22.9	54.2	12.5	3.66	0.8831
3	Autonomous maintenance is stepped perfectly.	2.1	27.1	18.8	43.8	8.3	3.291	1.030
4	TPM built more "ownership" for equipment.	2.1	12.5	14.6	54.2	16.7	3.708	0.966
5	No more breakdown maintenance.	14.6	43.8	12.5	25	4.2	2.604	1.143
6	TPM built teamwork spirit between operators and maintenance personnel.	0	8.3	25	62.5	4.2	3.625	0.703
7	There is improvement in production quality due to TPM.	0	8.3	16.7	62.5	12.5	3.791	0.770
8	Loss of assistant material is becoming less.	2.1	8.3	12.5	62.5	14.6	3.791	0.847
9	I received the proper training to do TPM tasks.	0	10.4	22.9	54.2	12.5	3.687	0.829
10	Skills of maintenance personnel and operators are increased.	0	16.7	22.9	52.1	8.3	3.520	0.847
11	TPM makes it easier to get the job done.	0	6.3	20.8	62.5	10.4	3.771	0.721
12	TPM is helping to improve equipment.	0	8.3	27.1	50	14.6	3.708	0.824
13	Your workplace is becoming safer and more comfortable.	2.1	10.4	18.8	54.2	14.6	3.687	0.926
14	Safety was stressed during training sessions.	2.1	12.5	25	25	35.4	3.791	1.129
15	There are supervision supports TPM.	2.1	14.6	16.7	47.9	18.8	3.666	1.017
16	You are satisfied about the current performance of TPM directorate and steering committees.	2.1	8.3	31.3	47.9	10.4	3.562	0.872
17	TPM should be expanded to other areas in my vision.	2.1	8.3	25	50	14.6	3.666	0.907
18	Other people in my area support TPM.	2.1	10.4	14.6	62.5	10.4	3.687	0.878
19	I feel confident doing TPM tasks.	2.1	10.4	16.7	60.4	10.4	3.666	0.883
20	I liked the way TPM was implemented in my area.	2.1	8.3	25	52.1	12.5	3.645	0.887

TABLE 5.39: TPM Activities and monitoring receptivity, Unit(TS- 5).

The main indications that can be generated from the questionnaire results (first part: TPM activities and monitoring receptivity) are:

was an improvement in the production quality due to TPM. About 77.1% of respondents (14.6% SA and 62.5% A) showed that the loss of assistant material in unit (TS-5) is becoming less. Whereas, 66.7% of respondents (12.5%SA and 54.2%A) believed that they received proper training to do TPM tasks. Skills of maintenance personnel and operators were increased, which was confirmed by 60.3% of respondents (8.3% SA and 52.1% A). About 72.9% of respondents (10.4% SA and 62.5%) agreed with the statement "TPM makes it easier to get the job done", and 64.6% of respondents (14.6% SA and 50%) believed that TPM is helping to improve equipment. On the other hand, 68.8% of respondents (14.6% SA and 54.2% A) confirmed that workplace is becoming safer and more comfortable. Regarding the safety, 60.4% of respondents (35.4% SA and 25%A) agreed that "Safety was stressed during training sessions". With regard to the supervision, only 66.7% of respondents (18.8% SA and 47.9%A) agreed that there was supervision that supports TPM. Very low percentage of 58.3% of respondents who were satisfied about the current performance of TPM directorate and steering committees. However, 64.6% of respondents (14.6% SA and 50%A) agreed that TPM should be expanded to other areas, and just 72.9% of respondents confirmed that the other people in their area support TPM. In relation to the feeling about TPM, 70.8% of respondents feel confident about doing TPM tasks. About 64.6% of respondents like the way TPM was implemented in their area.

5.4.8 TPM Factors, Unit(TS-5)

5.4.8.1 Top management commitment

In like manner to what has been performed to TS-4 unit, the top management commitment in TS-5 was measured throughout three questions. Respondents were asked to rate their extent of agreement or disagreement with the given statement concerning their top managers who dealt with TPM on a five-point Likert scale.
Table 5.40 includes three statements that were grouped to examine the attitude of the respondents regarding 'Top Management Commitment' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Top management of organization has a clear understanding of the concept of TPM.	6.3	50	14.6	22.9	6.3	2.729	1.086
Q2	There is a top management support to TPM.	4.2	56.3	18.8	20.8	0	2.562	0.872
Q3	Top management is willing to adopt the TPM concept.	0	6.3	39.6	50	4.2	3.520	0.683
F1	Top Management Commitment.							

TABLE 5.40: Top management commitment (Unit(TS-5)).

Table 5.40 illustrates the extent of degree of top management commitment in TPM adoption in LISCO (TS-5). The first statement "Top management of organization has a clear understanding of the concept of TPM ", (56.3%) of the respondents (6.3% SD and 50% D) disagreed with the statement with mean score of (2.73) and standard deviation of (1.08). In the second statement "There is a top management support to TPM", (60.5%) of the respondents (4.2% SD and 56.3% D) disagreed with this statement with

mean of (2.562) and standard deviation of (0.872). The third statement "Top management is willing to adopt the TPM concept" had a (54.2%) of the respondents (4.2% SA 50% A) that agreed with this statement with mean of (3.520) and standard deviation of (0.683).

5.4.8.2 Employee involvement

Table 5.41 illustrates the statements, that were grouped to measure the attitude of the respondents regarding the 'Employee involvement' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is employee involvement in management decisions.	4.2	43.8	25	25	2.1	2.770	0.950
Q2	There is awareness of TPM among employees in the organization.	0	25	20.8	39.6	14.6	3.437	0.936
Q3	TPM objectives are clearly identified to employees.	2.1	18.8	25	47.9	6.3	3.479	0.967
F2	Employee involvement.							

TABLE 5.41: Employee involvement (Unit(TS-5)).

Table 5.41 shows that about (48%) of respondents (4.2%SD and 43.8%D) were disagreed with first statement "There is employee involvement in management decisions", but there were (54.2%) of respondents (14.6% SA and 39.6% A) agree with the second statement "There is awareness of TPM through employees in the organization". In the third statement "TPM objectives are clearly identified to employees", where (53.2%) of the respondents (47.9% A and 6.3% SA) see that TPM objective are clearly identified to them.

5.4.8.3 Motivation, Rewards and Recognition

The scale of statement degree regarding this factor is displayed in Table 5.42, and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Employees are rewarded for the additional workload.	4.2	12.5	22.9	52.1	8.3	3.479	0.967
Q2	The organization has a motivation and reward system.	4.2	20.8	22.9	47.9	4.2	3.270	0.983
Q3	There is a general sense of high morale in the organization.	8.3	50	12.5	27.1	2.1	2.645	1.041
F3	Motivation, Rewards and Recognition.							

TABLE 5.42: Motivation, Rewards and Recognition (Unit(TS-5)).

Table 5.42 shows that 60.4% of respondents (8.3%SA and 52.1%A) were agreed with first statement "Employees are rewarded for the additional workload" , and there were

52.1% of respondents (4.2% SA and 47.9% A) agree with the second statement "The organization has a motivation and reward system ". In the third statement "There is a general sense of high morale in the organization", where 58.3% of the respondents (8.3% SD and 50% D) have disagreed with the statement.

5.4.8.4 Time allocation for implementation

Table 5.43 includes three statements that were grouped to examine the attitudes of the respondents regarding "Time allocation for implementation" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Sufficient time for implementation.	6.3	25	10.4	45.8	12.5	3.333	1.172
Q2	There is a clear understanding of time management.	10.4	43.8	39.6	6.3	0	2.416	0.767
Q3	Sufficient time for auditing TPM.	4.2	25	16.7	47.9	6.3	3.270	1.046
F4	Time allocation for implementation.							

TABLE 5.43: Motivation, Rewards and Recognition (Unit(TS-5)).

Table 5.43 shows that 58.3% of respondents (12.5% SA and 45.8% A) have agreed with the first statement "there was sufficient time to implementation", and there were 54.2% of respondents (10.4% SD and 43.8% D) that disagreed with the statement "There is a clear understanding of time management". In the last statement in this factor, 53.2% of respondents (6.3% SA and 47.9% A) agreed that there was sufficient time to auditing TPM.

5.4.8.5 Resource allocation for implementation

Table 5.44 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Resource allocation for implementation' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is availability of sufficient resources.	6.3	52.1	20.8	18.8	2.1	2.583	0.941
Q2	Effective practice of resource and material requirement planning system (MRP).	12.5	41.7	22.9	18.8	4.2	2.604	1.066
Q3	There is availability of main resources in the form of method analysis tools.	12.5	50	27.1	10.4	0	2.354	0.837
F5	Resource allocation for implementation.							

TABLE 5.44: Resource allocation for implementation (Unit(TS-5)).

Table 5.44 shows that 58.4% of respondents (6.3%SD and 52.1% D) disagreed about "There is availability of sufficient resources", and 54.2% of respondents disagreed that there was effective practice of (MRP) in the organisation. Only, 62.5% of respondents

confirmed that there is no availability of main resource in the form of method analysis tools.

5.4.8.6 Alignment to company mission

Table 5.45 includes three statements that were grouped to examine the attitudes of the respondents regarding the "Alignment to company mission" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The company business strategy align to TPM philosophy and principles.	0	4.2	31.3	56.3	8.3	3.687	0.689
Q2	There is strategic vision for the future about TPM in the organization.	0	4.2	29.2	54.2	12.5	3.750	0.729
Q3	Company policy committed TPM to meet customer requirements and continuous improvement.	4.2	14.6	27.1	52.1	2.1	3.333	0.907
F6	Alignment to company mission.							

TABLE 5.45: Alignment to company mission (Unit(TS-5)).

Table 5.45 shows that 64.6% of respondents (8.3% SA and 56.3% A) were agreed that the company business strategy align to TPM philosophy and principles, and about 66.7% of them believed that there is strategic vision for the future about TPM in the organisation. About, 54.2% of respondents agreed with the statement "Company policy is committed TPM to meet customer requirements and continuous improvement".

5.4.8.7 Performance measurement of TPM

The scale of statement degree regarding this factor is displayed in Table 5.46 and it shows the percentage of agreement and this agreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	TPM performance is noticeable to all participants.	4.2	25	16.7	50	4.2	3.250	1.021
Q2	There is TPM performance measurement.	27.1	35.4	29.2	6.3	2.1	2.208	0.988
Q3	TPM results give good impact to the participants.	0	0	10.4	72.9	16.7	4.062	0.522
F7	Performance measurement of TPM.							

TABLE 5.46: Performance measurement of TPM (Unit(TS-5)).

Table 5.46 illustrates that 54.2% (4.2% SA and 50% A) agreed that TPM performance is noticeable to all participants, and 62.5% of respondents(27.1% SD 35.4%D) believed that there was not TPM performance measurement at the plant. The majority of respondents (89.6%) (16.7%SA and 72.9%A) think that TPM results gave good impact to the participants.

5.4.8.8 Implementation plan and process

Table 5.47 illustrates the statements that were grouped to measure the attitude of the respondents regarding the 'Implementation plan and process' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is compliance with the master plan for TPM implementation.	6.3	54.2	25	14.6	0	2.479	0.824
Q2	There is an effective practice of TPM support tools (e.g. OPL, visual control system, Why-Why analysis, etc).	6.3	54.2	18.8	20.8	0	2.541	0.898
Q3	The plan of TPM implementation does not conflict with the general production plan.	2.1	25	22.9	43.8	6.3	3.270	0.983
F8	Implementation plan and process.							

TABLE 5.47: Implementation plan and process (Unit(TS-5)).

Table 5.47 shows that 60.5% of respondents (6.3% SD and 54.2% D) disagreed with the statement "There is compliance with the master plan for TPM implementation", and only 60.5% of respondents disagreed that there is effective practice of TPM support tools at the plants. Regarding the last statement in this factor, about 50.1% of respondents agreed that the plan of TPM implementation does not conflict with the general production plan.

5.4.8.9 Effective Communication

Table 5.48 includes three statements that were grouped to examine the attitudes of the respondents regarding "Effective Communication" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Communication between departments is effective.	6.3	47.9	14.6	29.2	2.1	2.729	1.026
Q2	There is a good communication from senior management level to employees.	8.3	47.9	27.1	16.7	0	2.520	0.874
Q3	There is an effective contact system between the company and customers.	2.1	14.6	20.8	52.1	10.4	3.541	0.944
F9	Effective Communication.							

TABLE 5.48: Effective Communication (Unit(TS-5)).

Table 5.48 shows 54.2% of respondents(6.3% SD and 47.9& D) believe that the communication between departments is not effective. Only, 56.2% of respondents said that there isn't a good communication from senior management level to employees. About 62.5% (10.4% SA and 52.1% A) agreed that "There is an effective contact system between the company and customers".

5.4.8.10 Integration with other manufacturing management programs

Table 5.49 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Integration with other manufacturing management programs' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Participants have knowledge about any other manufacturing programs.	12.5	54.2	18.8	14.6	0	2.354	0.887
Q2	The integration with other manufacturing programs has positive impact on successful implementation of TPM.	0	4.2	16.7	60.4	18.8	3.937	0.726
Q3	There is a link between TPM and other manufacturing programs.	0	4.2	29.2	58.3	8.3	3.708	0.682
F10	Integration with other manufacturing management programs.							

TABLE 5.49: Integration with other manufacturing management programs (Unit(TS-5)).

Table 5.49 shows that 66.7% of respondents (12.5% SD and 54.2% D) disagreed with the statement "Participants have knowledge about any other manufacturing programs", and 79.2% agreed that the integration with other manufacturing programs has positive impact on successful implementation of TPM. In the last statement in this factor, only 66.6% of respondent believe that there is a link between TPM and other manufacturing program.

5.4.8.11 Cooperation

The scale of statement degree regarding this factor is displayed in Table 5.50 and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is cross-functional cooperation between departments.	2.1	8.3	20.8	66.7	2.1	3.583	0.767
Q2	There is cooperation between the members of small group activity.	4.2	10.4	18.8	60.4	6.3	3.541	0.921
Q3	There is a good cooperation from the company partners.	14.6	47.9	14.6	20.8	2.1	2.479	1.051
F11	Cooperation.							

TABLE 5.50: Cooperation (Unit(TS-5)).

Table 5.50 shows that 68.8% of respondents agreed with the statement that said "There is cross-functional cooperation between departments", and only 66.7% (6.3% SA and

60.4%A) agreed that "There is cooperation between the members of Small Group Activity". About 62.5% of respondents disagreed with the statement that said "There is a good cooperation from the company partners".

5.4.8.12 Coordination and leadership

Table 5.51 includes three statements that were grouped to examine the attitudes of the respondents regarding "Coordination and leadership" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	There is an effective and expert leadership and coordinators.	0	10.4	22.9	54.2	12.5	3.687	0.829
Q2	The promotion of managers in departments within the company is based on qualifications.	10.4	41.7	12.5	29.2	6.3	2.791	1.166
Q3	There are full-time coordinators for monitoring TPM.	0	6.3	27.1	54.8	20.8	3.812	0.841
F12	Coordination and leadership.							

TABLE 5.51: Coordination and leadership (Unit(TS-5)).

Table 5.51 shows that 66.7% of respondents (12.5% SA and 54.2% A) agreed that "There was an effective and expert leadership and coordinators", about "The promotion of managers in departments within the company is based on qualifications", 52.1% of respondents were agreed with this statement. Moreover, 75.6% of respondents (20.8% SA and 54.8% A) agreed that there were full-time coordinators for monitoring TPM.

5.4.8.13 Cultural change, knowledge and beliefs and acceptance

Table 5.52 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Cultural change, knowledge beliefs and acceptance' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The receptivity to change of people towards TPM is acceptable.	0	16.7	12.5	52.1	18.8	3.729	0.961
Q2	Implementation of TPM program does not threaten your job security and increases the work load.	10.4	47.9	12.5	18.8	10.4	2.708	1.202
Q3	A bureaucratic culture is not prevalent in the organization.	25	45.8	20.8	6.3	2.1	2.145	0.945
F13	Cultural change, knowledge and beliefs and acceptance.							

TABLE 5.52: Cultural change, knowledge and beliefs and acceptance (Unit(TS-5)).

Table 5.52 shows that 70.9% of respondents agreed with this statement. Only, 58.3% of

respondent believe that implementation of TPM program does not threaten your job security and increases the work load. About a bureaucratic culture, 70.8% of respondent see that a bureaucratic culture is prevalent in the organization.

5.4.8.14 Availability of information and documentation

The scale of statement degree regarding this factor is displayed in Table 5.53 and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The organization has clear rules for the use of handling and updating of the information.	0	4.2	20.8	62.5	12.5	3.833	0.694
Q2	There is an effective practice of documentation system in the organization.	10.4	47.9	14.6 25	2.1	2.604	1.046	
Q3	The availability of information at the right time and right place.	16.7	54.2	12.5	16.7	0	2.291	0.944
F14	Availability of information and Documentation.							

TABLE 5.53: Availability of information and Documentation (Unit(TS-5)).

Table 5.53 shows that 75% of respondents (12.5% SA and 62.5% A) believe that "The organization has clear rules for the use of handling and updating of the information", and 58.3% disagreed that "There is effective practice of documentation system in the organization". In the last statement of this factor 70.9% of respondents were disagreed with this statement.

5.4.8.15 Empowerment

Table 5.54 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Empowerment' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Employees have been held more responsibility in their working environment.	6.3	14.6	20.8	52.1	6.3	3.375	1.023
Q2	Participants are empowered to make change in their work whilst performing their duties.	4.2	10.4	20.8	58.3	6.3	3.520	0.922
Q3	Giving power must be as much as holding responsibility.	2.1	8.3	22.9	52.1	14.6	3.687	0.902
F15	Empowerment.							

TABLE 5.54: Empowerment (Unit(TS-5)).

Table 5.54 shows that 58.4% of respondents (6.3% SA and 52.1% A) were agreed that "Employees have been held more responsibility in their working environment", and only 64.6% of respondents were agreed that "Participants are empowered to make

change in their work whilst performing their duties". About 66.7% of respondents believe that giving power must be as much as holding responsibility.

5.4.8.16 Formation of TPM office and Steering committees

Table 5.55 includes three statements that were grouped to examine the attitudes of the respondents regarding "Formation of TPM office and Steering Committees" factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Proper organizational structure has been developed to implement TPM.	14.6	43.8	18.8	22.9	0	2.500	1.010
Q2	An experienced directorate and steering committees.	12.5	43.8	25	18.8	0	2.500	0.945
Q3	There is interest of the committees about regular meetings.	16.7	47.9	20.8	12.5	2.1	2.354	0.978
F16	Formation of TPM office and Steering committees.							

TABLE 5.55: Formation of TPM office and Steering committees (Unit(TS-5)).

Table 5.55 shows that 58.4% of respondents (14.6% SD and %43.8 D) disagreed with the statement "Proper organizational structure has been developed to implement TPM", and 56.3% agreed that there were an experienced directorate and steering committees. Moreover, 64.6% of respondents said "There is interest of the Committees about regular meetings".

5.4.8.17 Existing maintenance system, equipment and workplace conditions

The scale of statement degree regarding this factor is displayed in Table 5.56 and it shows the percentage of agreement, disagreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The condition of the equipment is appropriate to apply TPM.	2.1	22.9	12.5	54.2	8.3	3.437	0.978
Q2	The condition of the workplace is appropriate to apply TPM.	4.2	52.1	20.8	20.8	2.1	2.645	0.933
Q3	Sufficient technology and the existing maintenance system is good.	8.3	56.3	14.6	20.8	0	2.479	0.922
F17	Existing maintenance system, equipment and workplace conditions.							

TABLE 5.56: Existing maintenance system, equipment and workplace conditions (Unit(TS-5)).

Table 5.56 shows that 62.5% of respondents (8.3% SA and 54.2% A) agreed with the statement that said "The condition of the equipment is appropriate to apply TPM", and only 56.2% believe that the condition of the workplace is appropriate to apply TPM.

Moreover, 64.6% of respondents (8.3% SD and 56.3% D) disagreed with the statement that said "Sufficient technology and the existing maintenance system is good".

5.4.8.18 Training and education

Table 5.57 illustrates the statements that were grouped to measure the attitude of the respondents regarding 'Training Education' factor. It reports the means of respondents in the sample regarding this issue.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	Sufficient quality training and education.	6.3	50	20.8	20.8	2.1	2.625	0.959
Q2	The organization trains its employees with a clear purpose.	10.4	52.1	14.6	20.8	2.1	2.520	1.010
Q3	Training targets in the organization are generally not achieved.	4.2 29.2	14.6	45.8	6.3	3.208	1.071	
F18	Training and education.							

TABLE 5.57: Training and education (Unit(TS-5)).

Table 5.57 shows that 56.3% of respondents (6.3% SD and 50% D) disagreed with the statement "sufficient quality training and education", and also 62.5% of them disagreed that "the organization trains its employees with a clear purpose", 52.1% of respondents (6.3% SA and 45.8% A) agreed that "Training targets in the organization are generally not achieved".

5.4.8.19 Union participation and acceptance

Table 5.58 includes three statements that were grouped to examine the attitudes of the respondents regarding the 'Union participation and acceptance' factor. It reports the means of respondents in the sample regarding this matter.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The trade union has a strong impact in your company.	14.6	37.5	27.1	16.7	4.2	2.583	1.068
Q2	The acceptance of the union can ensure TPM success.	2.1	10.4	22.9	56.3	8.3	3.583	0.8711
Q3	The Union cares about the employee.	8.3	47.9	27.1	14.6	2.1	2.541	0.921
F19	Union participation and acceptance.							

TABLE 5.58: Union participation and acceptance (Unit(TS-5)).

Table 5.58 shows that 52.1% of respondents (14.6% SD and 37.5% D) disagreed with the statement "The trade union has a strong impact in your company", and very low percentage of respondents 54.6% disagreed that "The acceptance of the union can ensure TPM success". About 56.2% ((8.3% SD and 47.9% D) disagreed with the statement that said "The Union cares about the employee".

5.4.8.20 Pilot project and gradual implementation on model machines

The scale of statement degree regarding this factor is displayed in Table 5.59 and it shows the percentage of agreement and this agreement, mean, and standard deviation for each statement.

No	Statement	SD %	D %	N %	A %	SA %	Mean	Std. D
Q1	The pilot project good results give confidence to the participants.	0	6.3	18.8	54.2	20.8	3.895	0.805
Q2	Pilot implementation can save time and effort.	0	4.2	22.9	52.1	20.8	3.895	0.778
Q3	Gradual implementation on model machines can be successful.	0	4.2	31.3	41.7	22.9	3.833	0.833
F20	Pilot project and gradual implementation on model machines.							

TABLE 5.59: Pilot project and gradual implementation on model machines (Unit(TS-5)).

Table 5.59 shows that 75% of respondents (20.8% SA and 54.2% A) agreed that the good result from the pilot project gives confidence to participants. Also 72.9% of them believe that "Pilot implementation can save time and effort". Also, 64.6% of respondents (22.9% SA and 41.7% A) agreed that "Gradual implementation on model machines can be successful".

5.4.9 Evaluating the factors affecting TPM implementation (Unit(TS-5))

In reply to the question 'Please specify how important do you think the following factors to implement TPM successfully in your company?', the results are illustrated below in Table 5.60 showing the ranking of these factors in Unit(TS-5).

No	Factor	Percentage SD	D	N	A	SA	Mean	Std. D	Rank
1	Top management commitment.	0	0	0	24	76	4.760	0.431	1
2	Employee involvement.	2	0	10	28	60	4.440	0.836	3
3	Motivation, rewards and recognition.	0	0	6	38	56	4.500	0.614	2
4	Time allocation for implementation.	0	0	12	58	30	4.180	0.628	10
5	Resource allocation for implementation.	0	0	12	62	26	4.140	0.606	12
6	Alignment to company mission.	0	4	22	34	40	4.100	0.886	14
7	Performance measurement of TPM.	2	0	10	42	46	4.300	0.814	5
8	Implementation plan and process.	0	2	14	46	38	4.200	0.755	8
9	Effective communication.	0	4	26	44	26	3.920	0.829	17
10	Integration with other manufacturing management programs.	0	6	26	42	26	3.880	0.872	18
11	Cooperation.	0	2	16	50	32	4.120	0.746	13
12	Coordination and leadership.	0	2	12	50	36	4.200	0.728	8
13	Cultural change, beliefs and acceptance.	0	2	18	36	44	4.220	0.815	7
14	Availability of information and documentation.	2	2	12	64	20	3.980	0.769	15
15	Empowerment.	2	0	18	58	22	4.240	0.921	6
16	Formation of TPM office and Steering committees.	0	2	38	40	20	3.780	0.789	19
17	Existing maintenance system, equipment & workplace conditions.	0	0	14	56	30	4.160	0.650	11
18	Training & education.	0	0	2	54	44	4.420	0.537	4
19	Union participation & acceptance.	14	28	36	12	10	2.760	1.152	20

20	Pilot project and gradual implementation on model machines.	2	2	14	28	54	4.300	0.931	5

TABLE 5.60: Evaluation of factors in Unit(TS-5).

5.4.10 Rank and mean for both units (Unit(TS-4)& Unit(TS-5))

The purpose of this step is to rank and review the various critical success factors of total productive maintenance (TPM) in favour of Libyan manufacturing industries for improving product and process quality. In this concern.

No	Factor	Mean	Rank
1	Top management commitment.	4.786	1
2	Training & Education.	4.428	2
3	Employee Involvement.	4.417	3
4	Motivation, rewards and recognition.	4.354	4
5	Pilot project and gradual implementation on model machines.	4.285	5
6	Performance measurement of TPM.	4.264	6
7	Existing maintenance system, equipment & work-place conditions.	4.132	7
8	Implementation plan and process.	4.131	8
9	Resource allocation for implementation.	4.111	9
10	Coordination and leadership.	4.110	10
11	Cultural change, beliefs and acceptance.	4.099	11
12	Time allocation for implementation.	4.079	12
13	Cooperation.	4.049	13
14	Alignment to company mission.	4.956	14
15	Availability of information and documentation.	3.927	15
16	Empowerment.	3.917	16
17	Effective communication.	3.876	17
18	Formation of TPM office and steering committees.	3.754	18
19	Integration with other manufacturing management programs & acceptance.	3.742	19
20	Union participation & acceptance.	2.952	20

TABLE 5.61: Rank and mean of TPM factors - Units(TS-4 & TS-5).

From the data analysis, it can be observed that each factor plays a critical role in successful implementation of TPM in the manufacturing industries.

Table 5.61 shows the rank of each factor given by the manufacturing industries. It shows that the 'Management Commitment' factor is the prime objective of most of the respondents, then comes 'Training & Education', 'Employee Involvement', 'Motivation', 'Rewards and Recognition', 'Pilot Project and Gradual Implementation on Model Machines', 'Performance Measurement of TPM', 'Existing Maintenance System', 'Equipment & Workplace Conditions', and 'Implementation Plan and Process'.

At the end of this table comes the 'Union Participation & Acceptance' factor (Figure 5.13), which has a very low percentage. This result agrees with what was found

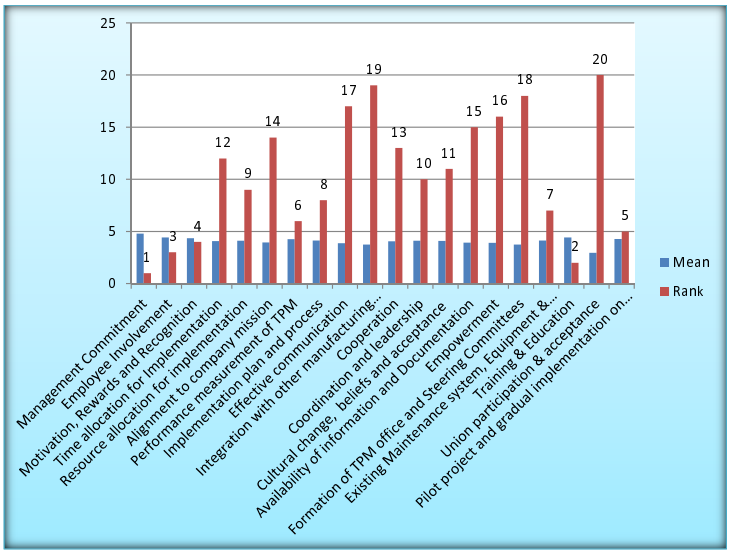

FIGURE 5.13: Rank and mean of TPM factors - Units(TS-4 & TS-5).

in the interview, where this factor has no effect on the Libyan manufacturing environment.

In general, most of interview results were consistent with what has been found from the questionnaire results and document review, indeed this consistency works to enhance the research findings. Hence, from the questionnaire results, the researcher generated a number of statements. Those occurring with the highest frequency across the majority of the classes of respondents are identified. Selection was based on those statements where more than the half of the participants from one or both case studies addressed the issue as a concern. These statements were asked to assess the respondents' thinking on TPM implementation, common factors or obstacles were facing each organisation and, the main TPM activities' supporting tools related to the program and its improvement in each case study organisation.

5.5 Conclusion

It was revealed through the study that there is a gap within the TPM research which was highlighted by investigating the implementation of the TPM principles. This chapter contained complete briefing of the implementation of TPM and has also elaborated on how the organisational barriers limited or affected the implementation of TPM.
The significance of management experience has been highlighted in the study such as strengthening the supervision of TPM and top management commitment, particularly considering the measures required at every step or level of implementation. Moreover, the results obtained through the study suggest that the hurdles faced at the individual level helped better in the prediction of the TPM program, and hence it can be said that the significance of such barriers and factors can be more than it is stated. Basically, the results suggested that the response of an individual to the TPM would be affected by the balance within the organisational and individual perspective, background and experiences.

The study, also, suggested or addressed the need for training of the managers specifically within the Libyan Iron and Steel Company (LISCO). The study, also, highlighted the need for maintaining a positive relation within the organisational culture and employees. Further, consideration from the organisation is required for developing better training and practices for the TPM and its framework while considering the social and economic factors that would affect the implementation of TPM specifically within Iron and steel company.

The next chapter will demonstrate the discussion of all the data linking the results we have from the literature with the interviews, questionnaires, and documents survey. Some unique findings about the implementation of TPM in Libyan environment will be discussed and summarised. Also, the list of obstacles and barriers to TPM in LISCO will be revealed. Furthermore, revising the theoretical framework and list of ranked TPM factors will be included.

Chapter 6

Discussions and implications

6.1 Introduction

This study, potentially, would have an important research outcome. Correspondingly, this Chapter discusses the research findings and its connection to previous studies related to the same subject which was discussed in the literature review chapter. Moreover, the discussions in this Chapter would concentrate on the main aim and the related objectives of this research.

6.2 TPM factors and activities

6.2.1 Top management support and commitment to TPM

Most of the interviewees believed that based on the level of education, experience and other criteria of job specifications, the top notch position and vacancies occupied by those individuals who may not be fulfilling the required mentioned criteria. Accordingly, the leadership is not effective which results in unsuccessful management.

In fact, both responses from the two units matched and agreed to the lack of presence of any effective and efficient management and leadership in there units. They, however, were not very eager to respond to the questions that pertain to the overall evaluation of their managers or leaders from the top management. Instead, most of them either avoided to answer or gave their answer in such a way that makes it sound innocent of blaming directly the top management being afraid of the consequences that might cause the loss of their jobs. This is also true due to the fact, as per the respondents, that most of the recruitment of the senior level is accomplished by the Ministry under the direct or indirect supervision of the government.
In fact, this is caused by the deep rooted corruption where most of the seniors' positions, decision-making and strategic positions are not occupied by those who may fulfil the required educational and experience criteria, but rather by those who have political relations or have been associated with the powerful people.
Again, these responses matched when checked with the education records of the top management and that required as per job specification.

Actually, within the country, the extent of decision making power in organizations depends entirely on individual basis. In particular, this will solely depend upon the relationship that the decision-maker enjoys with the Ministry, the Central Bank or those concerned within the government ranks. Further, when an individual is brought from outside and placed on the top at the helm of affairs, there is an increased probability

that he would lack the relevant experience and may even be lacking the required educational background which may jeopardize the future of the organization both in the short and long run. Moreover, the reinstatement of such individual may even result in the lack of spirit in the same individual as he himself may not be motivated enough due to his inability to comprehend the situations because of his inexperience and lack of education. As a consequence for this basic and obvious question, many of technical staff have answered "do not know". This could be referred to some neglect or lack of trust between employees and top management. Despite this shortcoming of most of the senior management, but they all have the desire to apply TPM system as well as all the interviewee agree with many authors such as Bamber et al. (1999), and Piechnicki et al. (2015) who mentioned that management commitment and support is one of the key factors for the success of TPM implementation.

6.2.2 Understanding TPM and its benefits

Based on this research it can be easily concluded that the top management was unable to deduce the fundamental purpose of the application of TPM within the workers and the departments at large. Instead of instilling the employee with the core understanding of TPM and its applicability in the long run, the management was looking forward to seek the stamp of the TPM certification. This would prompt and enable them to trumpet and proclaim themselves as the one coming up with the new changed system. However, they were not willing to continue and proceed with the same system. They would opt for the current quality system and certification but instead of implementing and further improving on it, they would take it as an alternative to the entire Total Quality Management. Thus, it is only rational that managers of such organizations focus more on letting the people in the same organization and within the sector knows about their so called accomplishment of getting a certain certification. According to Jackson (1999) cited in Pomorski (2004), the Integration between TPM and other continuous programs such as TQM and JIT to achieve the greatest improvements in quality, reliability, cost, and time. This would help these managers in attaining high profile lucrative jobs in the higher management for a considerable stretch of time.

There was a consensus among those responding that the application of TPM would enable and increase the efficiency and effectiveness of the overall maintenance activities. This would be due to the fact that documenting and registering along with the likely superior communication, would enable both the employees and the department to breach another level of excellence. Thus, for getting better result with increased performance, high quality and augmented productivity, it is only deemed necessary for the organization to continue with the application of TPM for a longer stretch of time for every department rather than using it as a quick fix and abstaining to continue the same after a while.

Just for the sake of being involved in the survey, most of the participant from the highest tier of the management claimed that they were well acquainted with the management principles inclusive of the TPM and TQM, while few, on the other hand, consider it unworthy of their calibre to even attend the relevant programs. Hence, it can be easily deduced that there was a complete or partial lacking on the realization of the managers belonging to the top tier of the organization and thus their inability to recognize its benefits and advantages as well. However, the middle and lower tier seemed upbeat and ready to get instilled with the understanding of the TPM processes.

Hence, we can safely say that the bulk of the responses from both the organization pointed out that there was a lack of understanding and ample requirement for the organization to facilitate their employees in educating them with TPM.

When asked, most of the respondents claimed that the higher management in their organization do not require any training or information concerning TPM. They do not place TPM as a necessity or priority to be understood and implemented. According to Piechnicki et al. (2015) providing the whole employee (managers and operators) with training and education is indispensable in the preparation phase of the implementation. This results in incomplete dedication of the top management in understanding and getting acquainted to the TPM; so far so that they do not propel the middle management in pursuing it as well. Since there is lack of understanding the benefits of TPM, they consider it as a certification to get it over with. They would rather consider it as a tool for the middle management to complete and apply for the promotion in the senior management cadre. Thus they pay little, if any, importance to the individual performance in TPM and how they tend to delegate and transfer it to other individual in the team, department and the organization for that matter. The top management would consider the dealing of the issues pertaining to TPM as the matters and job responsibility of the members and employees exclusively in TPM. For them it is never a matter for the managers to deal with; thus they would never consider it appropriate for the managers to be associated with such a change from the beginning of its implementation.

According to the responses the recommendations and advices put forward by the TPM team was not even considered by the top management. This was in conjunction to the fact that they were however realizing the issues that were cropping up that needed timely TPM intervention. Even then there was lack of funding to the TPM. It was quite evident that although the top management was promising and giving words to introduce and continue with the TPM, however there was not any sincere effort on records or planned in future to do so.

6.2.3 Managing TPM activities

The implementation process of TPM is usually represented in the form of a framework that has a certain pillars. This framework can act as a guide and it provides a structured way to achieve certain objectives. A review of literature revealed that different frameworks of TPM pillars are available. Among these, very few frameworks were proposed by academicians, while most of them were suggested by consultants who have developed these frameworks based on their experience with different organisations. These frameworks of pillars are assumed to be generic in nature because the consultants will be providing maintenance consultancy to different types of industries in different parts of the world. Unless it is generic in nature, it cannot be applied uniformly to different types of industries.

In this LISCO case study, four pillars out of eight have been applied in the TPM program as recommended by the consultant, namely, focus improvement; autonomous maintenance; planned maintenance; safety, health and environment control, and recently they have added the fifth pillar which is education and training.
TPM teams have been formed in each plant to deal with the selected model machines according to the schedule indicated by the master plan. The structure of the application

(implementation committees and task forces) formed in accordance with the structure of pillars and implementation of the program in factories and units. This crosses with what was found in the literature review of this research.

Mishra, Anand, and Kodali (2008) have shown a list of 20 different frameworks that have different pillars. These frameworks of pillars were compared and it was found that only few frameworks are unique while in others, the naming and the number of pillars/elements differ slightly. Also this research found that each framework has its own strengths and weaknesses. The literature review said that the entire edifice of TPM is built and stands on these pillars, which can be any number of pillars depending on the level of implementation and the target of your TPM award (Pomorski, 2004) (Ahuja and Khamba, 2008c). In accordance with the assessment criteria of JIPM, depending on the category of the reward, companies that have introduced TPM and are applying for TPM award, they must achieve eligibility and requirements for each category. The main two eligibility are:

- They must have deployed an activity based on the 5 pillars of TPM focusing on the production site (focus improvement; autonomous maintenance; planned maintenance; education and development; safety, sanitation and environment control) for category B;
- They must have deployed an activity based on the 8 pillars of TPM by all staff members of the plants (individual improvement; autonomous maintenance; planned maintenance; initial management; quality maintenance; administrative and supervisory department; education and development; safety, sanitation and environment control) for category A (JIPM, 2010).

In fact, the middle managers and TPM interviewees see that the first five pillars that were implemented in LISCO are related directly to the productivity which was the main reason behind applying such program. Moreover, they believe that autonomous maintenance can give operators greater "ownership" of their equipment, increases operators' knowledge about their equipment, ensures that equipment is well-cleaned and lubricated, identifies emergent issues before they become failures, and frees maintenance personnel for higher-level tasks. On the hand, some operators see that as an overload work, and some maintenance personnel see that as first step to dispense with their service.

The planned maintenance can significantly reduces instances of unplanned down time. It also, can enable most maintenance to be planned for times when equipment is not scheduled for production, and reduces inventory through better control of wear-prone and failure-prone parts. The majority of middle managers and TPM coordinators interviewees have seen the focused improvement has small groups of employees work together proactively to combine the collective talents of a company to create an engine for continuous improvement, and its recurring problems are identified and resolved by cross-functional teams.
Also, TPM coordinators agree that, the training and education pillar can fill in knowledge gaps necessary to achieve TPM goals, which applies to operators, maintenance personnel and managers. Most interviewees were looking at safety, health, and environment as additional activity that can eliminates potential health and safety risks,

resulting in a safer workplace, also it could specifically target the goal of an accident-free workplace (SMMT, 2014).

There are a variety of tools and techniques that are traditionally used for improvement. It provides an easy way of deploying activities through its TPM promotion organization involving the employees on a continuous basis. (Simo~es, Gomes, & Yasin, 2011) referred to (Raouf and Ben-Daya, 1995) who mentioned that the literature review tended to confirm the importance of certain tools and techniques in relation to organizational maintenance and its role.
In Libyan Iron and steel company, TPM uses the following tools to analyze and solve the equipment and process related problems, these tools have been used as suggested by the expert, which was found in the document :

- One Point Lesson (OPL);
- Statistical process control (SPC–control charts);
- Activity Board;
- Cause-Effect diagrams and 5-why;
- Plan Do Check Act;
- Poka-Yoke systems;
- 5S;
- Computerised Maintenance and Management System (CMMS);
- OEE;
- Tagging.

Regarding these tools, it has been found that there is a clear need for the use of 5S's tool to focus on organization cleanliness and standardization to optimize profitability and efficiency and safety and service. Visual controls play a key role in the 5S process by providing an effective tool to remove clutter and organize the workplace.

In the case study, there where lack of use in activity boards which are a specific type of visual control that is commonly utilized in TPM. JIPM refers to activity boards as a guide to action. They present the TPM team with a visual guide to its activities that makes the [improvement activities] so clear that anyone can immediately understand them (JIPM, 2010). Activity boards are posted so that the employees easily access them. They are typically located in the work area or common areas where employees meet (Pomorski, 2004). Another common visual control tool that is used in Autonomous Maintenance is the One Point Lesson (OPL), which was used in the case study, and it gave good result. It is one of the most powerful tools for transferring skills (Robinson and Ginder, 1995). Moreover, OPL is a tool to convey information related to equipment operation or maintenance knowledge and skills.

The idea behind the yoke poke is to liberate the mind of a person to maintain repeated vigilance, which is often not feasible. That person can do the work without fear of making mistakes, which can constructively contribute more value-added activities. The literature review introduced computerized maintenance management systems (CMMS)

that included many of the features required to support the maintenance management and performance measurement system (Labib, 2004).

6.2.4 TPM performance

The responses from the interviewees highlighted the fact that the performance indication reports which are used by the organization departments can be easily manipulated and formed by the person who is responsible for issuing them for the purpose of hiding any inconsistencies or errors, and also these reports can be adjusted according to the managers' intensions and wishes. For instance, this would be done to falsely highlight the growth and performance appreciation in that particular department. In fact all respondents agreed that there was manipulation in the said reports making the performance look at its best status. They also suggested that since the reports were based on the data that was attained using the already selected variables by the department, it would not comprehend how well the performance was, but rather it was only highlighting the current progress without any comparisons, and further, only those aspects which would make the top management look good would be put forward in these reports.

The main reason for the occurrence of the same strategy is because that reports, time sheets and job sheets are being used to measure the efficiency and effectiveness that is brought about by the managers without actually measuring the real difference. On the other hand, the TPM processes would incorporate rational methods like OEE and other statistical techniques for measuring the performance.

There was, yet, another accord between respondents represented in that the TPM performance evaluation is performed individually which, however, is not feasible and applicable due to the fact that TPM is a joint process. The survey research, also, found that there was no measurement gauging system of any sort relevant to the TPM applicability that would ascertain the performance of the same in the organization. This situation was same in both units. Hence, the respondents, also, promoted the idea of using the OPE or overall plant effectiveness and the total outcomes and results of the organization as an indicator for TPM performance measure. Ironically, it was also mentioned that both the respondents from TS-4 and TS-5 units considered that the organization is not coming up with actual TPM performance and the respondents, at large, were unhappy with the performance measurement of the entire organization. Shafeek (2014) said "What cannot be measured cannot be improved".

The interview, also, implied that there was no acceptance to improve the quality of the program or to continue with the improvement program in the maintenance area of the organization. Moreover, the only tool available for measuring and evaluating the performance and comparing it with the previous ones, thus setting it as a bench mark, was the monthly and annual operating reports. However, even these reports would not highlight the performance of the company in terms of continuous integrated processes.

The top management would not consider TPM as a priority but as a liability on the balance sheet and thus paying less heed to improve the processes. However, with the ISO 9000 certification for quality system, many managers try their best to implement and continue with the quality improvement processes. These managers have to cope up with other internal and external factors including environmental, political, social

and political factors and even lack of skills and qualifications. Furthermore, the management should go against the traditional thought process where TPM was considered a costly process and try to consider it as an adding value to the systems and overall organizational output.

Although there was difference in the time duration, both the TS-4 and TS-5 units suffered a delay in production subsequent to the lack of performance in the maintenance. Therefore, the lack of resources and performance of the staff members in the maintenance department was put forward as the probable causes of the delay. Moreover, there were many issues, that were checked from the organization's recorded documents, which required detailed supervision and planning to be in place to improve the performance. However, that was not the case, but instead, the lack of any maintenance planning and procedures acted as a hurdle to improve the performance. One of the reasons is the lack of funds which also resulted in the resources being used for the on hand issues rather than focussing on the future planning.

In both the TS-4 and TS-5 units, employees were not motivated enough to collect, analyze, interpret and put forward the relevant data concerning the required improvement in the maintenance and the issues to be tackled in front of the top management. Furthermore, the OEE was not used and hence making it impractical to measure the advancement. Further, the six big losses and other problems remained overshadowed since there was no work done to identify and tackle them effectively and efficiently.

6.2.5 The organizational policy and the socio-cultural impact

The effect of the family ties, nepotism and personal relationships while hiring the top tier management was quite evident from the conducted research, and these social relationships do play a pivotal role in the management processes. It was even more striking that more than the one third of the respondents were actually hired through social or personal relationship. Hence, understanding socio-cultural aspects of the country becomes essential when trying to understand the management and quality function of the organizations.

Regardless of the changes in the overall Libyan society and economy, the role of socio-cultural factors, relationships, friendships, tribal connections and nepotism are still evident in their grassroot level. Moreover, since most of the employees themselves were offered job based on their connections and relationships, it can be assumed that issues like absenteeism, carelessness and corruption would only increase (Mohamed, 2005).

The overall vision of TPM removes any "conflict of interest" between maintenance and production departments. If the goal is to improve the performance of the production line, it is important to integrate the two activities in a comprehensive strategy (Graisa and Al-Habaibeh, 2010). It is expected that considerable difficulties will exist when TPM is implemented in factories in Libya due to the fact that, the TPM concept is alien to Libyan workers and managers in LISCO, and Secondly because the redefined roles of production operators and maintenance department require a fundamental change of the organizational culture. Aspinwall and Elgharib (2013) shows that culture change has been the main obstacle for implementing TPM.

When such relationships dominate the hierarchy and organizational setup of the employees, then it becomes difficult to control and carry out the functions in a proper way that translates into peak performance. Eventually, the complete scenario could be summed up by understanding that although the organizations were over staffed against the number of jobs available, but individually and collectively they lacked the complete set of associated and required skill of the occupied jobs. Also, the state puts its influence forward and posts their favoured people in the industry which is, regardless of all, part of the local inherited culture. Moreover, the worsened up situation was recognized by the employees as well but they also accepted the fact that certain norms of the socio-cultural environment can not be changed instantly.

The lack of vision and leadership from the top management consequently resulted in the lack of employee motivation, involvement, and delegation and also resulted in discontinuation of the training, improvement and system maintenance programs, as per the responses from those who were interviewed. According to the middle, first line manager and others involved in the survey, the top tier leadership did not take steps to encourage the employees to come up with solutions and motivate the workers with rewards. This, again, results in the work force would rather prefer to shy away from getting involved and getting empowered in the decision-making process of the organization.

In fact, the interviews confirmed some major issues with regard to training, financial incentives, and measurements of pollution and shortage of social activities which confirms the findings considered in the literature review (Pomorski, 2004).

6.2.6 Management information system and communications network

For any organization, availability of a good and updated information system is mandatory. This is because pertinent and timely information tend to improve the total quality and decision making processes. The MIS system would ensure that the timely provision of the changes that may incur or deliberately made will improve upon the systems in place and this will improve the overall quality and enhance the performance. However, the respondents responded with complain of poor sub-standard in-situ internet connections as well as about the typical paper-based traditional and out-dated systems used. Consequently, no support is gathered from the information system and the lack of a system here hinders the maintenance as well as the collection and analysis of the data that may be crucial for the organization in key decisions. Therefore, without any support from the information system, the quality of the decisions and equipment maintenance tends to deteriorate.

Many of the benefits that would be part of the information system were missing from the case study due to the obvious lack of technology at the related two units. However, in order To work at the optimum best, the presence of information technology system is of extreme importance to the maintenance department to complete their tasks efficiently and effectively. It can be safely concluded that effective and workable communication technology is of key importance to the process of change. If this would be in place, the system would ensure that all the processes initialized would be documented from the very beginning. Those involved in the process of change would, themselves, be all well informed about their development and advancement from the very beginning. Hence, it is of utmost importance to understand the communication

process comprehensively and continue it with intact integrity. Moreover, the interpersonal and communication skills are of importance when hiring a team to perform a certain task on the long run.

The respondents also claimed that the communication as in the case of maintenance department was very poor and the relevant strategies, processes and methods were not communicated properly to the employees.

6.2.7 Resistance to change

Naturally, the resist to changes takes place in everyday situations at work place or in day life in general, especially when no previous knowledge exists regarding this change. Though, most of the interviewees rapidly accepted the idea of bringing improvement and success to their organisations. In the whole, TPM needs for facilitating improvement and change, and this belief can only be reinforced through education, awareness, training and practice. Thus, the TPM should take place in orientation program for new production staff to consolidate change process.

Moreover, continuous training at all levels of the organization will help to overcome the reluctance and resistance to TPM. Some operators neither had the aptitude nor the attitude to take up their new role properly due to the fact that in LISCO, operators did not receive any extra payment for the performance of TPM tasks.

For most production employees, TPM means doing more work but without any more money. Cooke (2000) realized the same and found out that one major reason for operators' resistance to TPM is linked to the compensation issues. The study revealed that there is a general resistance to change by operators and maintenance staff due to the new tasks assigned to them and the redefinition of the roles of each department. Further, Cooke (2000) discovered that some operators take responsibilities in basic maintenance tasks represents a unilateral practice teamwork and cooperation. Furthermore, Ahuja and Khamba (2008) and T. Bartz and Barth (2014) agreed that, it is difficult and laborious to keep the program of implementation of TPM running successfuly in long term. This can be attributed mainly to cultural factors and the employee involvement. The production personnel considered that as unfair and one-sided act that they had to share the work with maintenance, but maintenance never shared operators work.

In LISCO, it can be noticed that people did not accept the TPM concept as a consequence of thinking that TPM will increase the workload of operators aiming to run the organization with fewer maintenance people. This can be attributed to the lack of TPM know-how and lack of understanding TPM principles which in turn produced a lack of interest and motivation. Considering the maintenance department, the majority of maintenance technician are reluctant to transfer skills and responsibilities to production operators. Moreover, maintenance technician are sceptical about the ability of operators to practice preventive maintenance, which led to the situation that technicians did not want production operators to get their hands on the equipment and preferred them not to touch anything.

6.2.8 Barriers and obstacles to TPM in LISCO

The implementation of TPM is not impossible to succeed in many companies in different countries such as Japan and the United States, many European countries, India, Malaysia, and South Africa, but implementing this system coincided with the number of failures in some of these countries also. Discussing the results obtained from these countries can help in identifying barriers to effective implementation of TPM in Libyan manufacturing Companies.

This section contains more elaboration of the hurdles faced during the implementation of TPM in LISCO. The results obtained would be brought under discussion in the light of the literature review to better understand the level of the barriers faced during the implementation of TPM and how much they resemble with the issues highlighted within Libyan Iron and Steel Company specifically regarding TPM and its implementation.

Considering the main objectives of the research and the methods and techniques stated to achieve those objectives, the perception of the employees and the management regarding TPM system have been evaluated at Libyan companies, in addition to the barriers that the organisations have to face with TPM system and its implementation which mainly occurs when the organisations neglect the basic information and knowledge required or associated with TPM systems. Hence, to obtain and understand the findings and results of the study, a framework was developed by the researcher.

Graisa and Al-Habaibeh (2010) in their cement case study in Libya found that the vast majority of the fluctuation in the factories' production was based on the change in shift hours, equipment failure and shortage of spare parts. The analysis showed that there was a clear indication that there is a need for TPM in order to keep the productivity on a stable and higher level. With regard to the above result from the document review, interviews and prior research such as Cooke (2000), Bamber, Sharp, and Hides (1999), and Ahuja and Khamba (2008c), the barriers and obstacles to TPM implementation are as follows:

- The weakness of senior management's support for the foundation for TPM implementation;
- The lack of top management commitment and understanding (e.g. allocation of resources, purpose of TPM);
- The failure to allow adequate time for the evolution;
- The inability to create a cooperation atmosphere between maintenance and operation, which is not conducive to the application of autonomous maintenance by operators;
- The lack of wage systems and incentives to encourage operators to participate effectively in TPM;
- The wage payment system based on production rates;
- The proper training of employees to be able to implement this system. This training includes the training of operators and maintenance work to raise the competence and training of staff in general to make them aware of the benefits of TPM components and how they are applied;

- Introduction of TPM on too many machines at the same time;
- Expecting very quick results. Usually it needs some investments in the beginning to carry out cleaning and rehabilitation to good condition, and then the results of these investments will come gradually thereafter in the form of reducing waste, increasing productivity and improving quality;
- Lack of good metrics to measure the impact of the application of TPM;
- Absence of strong structure and relationships to strategic needs;
- Partial application of TPM;
- Taking on more responsibilities and skills transfer generated resistance to change among employees.

6.2.9 Some unique findings regarding the implementation of TPM

This research concluded some findings which were extracted and summarized from the LISCO TPM monthly reports that the author was granted access to, and they are considered to be unique. These findings are summarized hereinbelow:

- Low participation of engineers' partner (ISPAT) who are at productive sites in the follow-up and activation of the TPM implementation. Note that the expert partner who was mentioned in the Convention, has started work with LISCO as of summer 2010, which is considered as unique case;
- Delayed implementation of weekly reports from some points of execution caused the delay in the preparation of the monthly report of the supervisory committee;
- Accumulation of materials and equipment used at production lines. This issue is due to the urgent need of these parts, which has become difficult to obtain from its maker as a result of aging. The need to continue to follow and monitoring the way of re-storing equipment parts that can take advantage of them, outside the work area and production lines in order to create an environment to work and reduce the cost of accidents and reusing these parts;
- The difficulty of applying autonomous maintenance (cleaning) at some areas of the plants, because of the high proportion of calcification dust on equipment and props and contamination of ground factories around the equipment;
- Need to embark on granting incentives (moral and material) to members in accordance with the methodology (to complete development of a proposed mechanism), and to reconsider the decision to cancel the annual benefits division of LISCO to workers;
- The need to update the job description of the company's employees in accordance with the methodology of the program of TPM;
- The need to include activities (Total Productive Maintenance), weekly and monthly reports of the sections and departments and discussed within its regular meetings;
- The need for the implementation of workers and encourage them to provide and implement proposals to improve their work sites.

6.3 Revising the theoretical framework

Most of the key elements constituting the TPM framework discussed earlier in Chapter 3 , i.e. TPM pillars, TPM effectiveness, TPM foundations, and TPM targets (Figure 3.3). Moreover, the TPM definition, main barriers of TPM implementation were discussed therein as well. Further, these topics were investigated in relation to the environment of the case studies subject of this research.

This empirical study produced some findings that showed significant consistency when compared to the initial framework. Howbeit, these findings showed significant differences in the TPM barriers and factors, and hence, the initial framework has to be revised and improved (Figure 6.1).

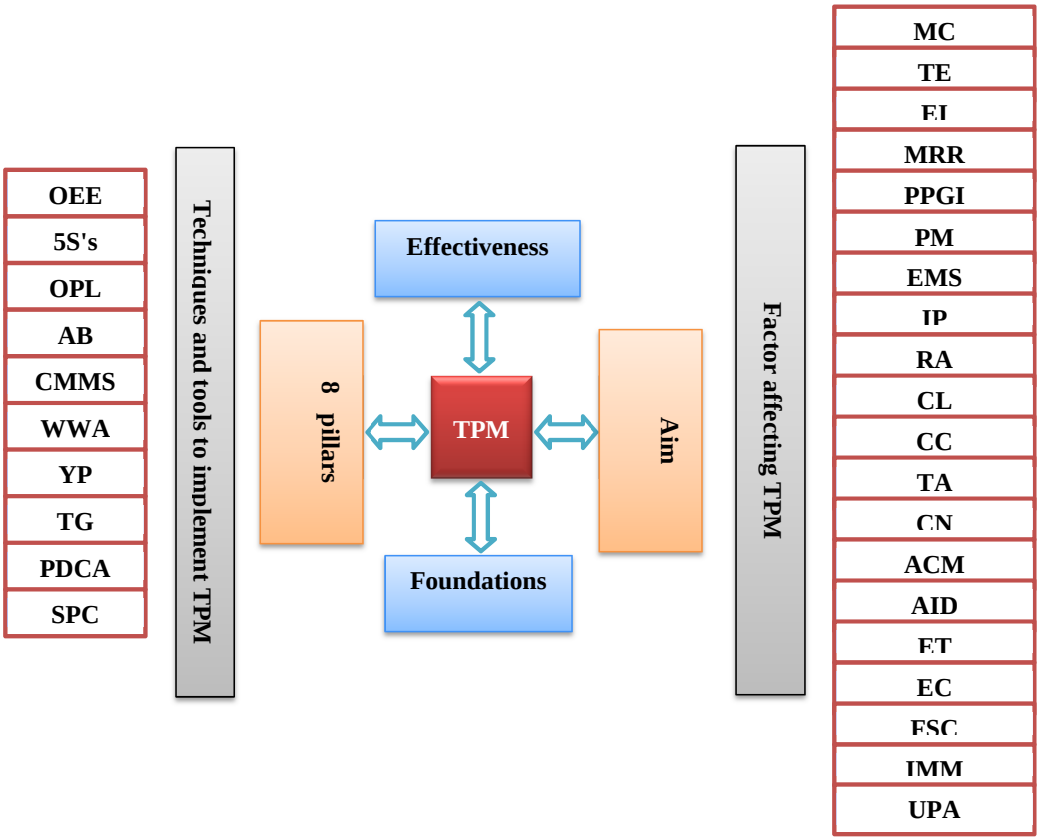

FIGURE 6.1: Revised TPM framework.

6.3.1 List of revised TPM pillars

1. Focused Improvement;
2. Autonomous Maintenance;
3. Planned Maintenance;
4. Education and Training;
5. Safety, Health and Environment;

6.3.2 List of ranked factors affecting TPM implementation

According to the findings of this study, the ranked factors that directly affect the TPM implementation in LISCO are:

1. Management Commitment (MC);
2. Training & Education (TE);
3. Employee Involvement (EI);
4. Motivation, Rewards and Recognition (MRR);
5. Pilot Project and Gradual Implementation on Model Machines (PPGI);
6. Performance Measurement of TPM (PM);
7. Existing Maintenance System, Equipment & Workplace Conditions (EMS);
8. Implementation Plan and Process (IP);
9. Resource Allocation for Implementation (RA);
10. Coordination and Leadership (CL);
11. Cultural Change, Beliefs and Acceptance (CC);
12. Time Allocation for Implementation (TA);
13. Cooperation (CN);
14. Alignment to Company Mission (ACM);
15. Availability of Information and Documentation (AID);
16. Empowerment (ET);
17. Effective Communication (EC);
18. Formation of TPM Office and Steering Committees (FSC);
19. Integration with Other Manufacturing Management Programs (IMM).
20. Union Participation and Acceptance (UPA).

6.3.3 TPM tools and techniques

According to the findings of this study, the TPM tools and techniques that directly affect the TPM implementation in LISCO are:

1. OEE;
2. 5S's;
3. One Point Lessons (OPL);
4. Activity Board (AB);
5. CMMS;

6. Why-Why Analysis (WWA);
7. YokE-PokE (YP);
8. Tagging (TG);
9. PDCA;
10. SPC.

6.4 The Cost Benefits and The Effectiveness of TPM framework

Cost benefit analyses usually uses monetary criteria to evaluate all considerations. This path works well in traditional economic analysis where most factors can be easily quantified. However, when non priced values are considered, the practice of valuing all inputs to a cost benefit analysis in monetary terms becomes unworkable.

The adoption of Total Productive Maintenance is not easy, as it represents a radical change in the culture of organizations, because they require the management to change its program and let the staff learn from the experts during the performance of work, as the continuous improvement requires a new way to manage the work. This does not involve just issued orders to employees, but must ask them to think about, and participate in, the process of organizing the work, because all members of the organization, in accordance with the principle of TPM, may have been trained within the organization and therefore it is expected from them to analyze the processes and work together for the improvement and development, as well as to focus on autonomous maintenance and participation of employees.

Successful implementation requires the participation of every person who has a direct or indirect impact on the effectiveness of the equipment. Everyone should know the value and importance of the performance and reliability of the equipment and their role in this area.

The final outcome of the comprehensive maintenance system shows that taking care of the equipment by the operators is of great importance. Moreover, the findings also showed that the performance and reliability of equipment are the main pillars of the competitiveness in all activities, whether productive, commercial, residential or public services. As a result, it will increase equipment reliability and reduce operating costs and will enable the business forecast and makes humans focus on raising the overall effectiveness of the equipment.

The achievement of all this comes through creating an appropriate environment for the application of this new concept with its new cultures, as well as, the promotion of the program by organizing lectures, conferences or training sessions to introduce the concept of TPM and its benefits to the organization.

In fact, the costs of the implementation of TPM programs are difficult to determine because of the overlap between the production process and the maintenance process. However, Ingalls (2013) talking from his experience and replying to the question "what

is the typical cost of TPM implementation?", he mentioned that, in particular as a consultant to hundreds of plants since 1991, it has been shown that an expected start-up cost can be estimated to about 10-20% increase of budget in training and about 15% increase in maintenance costs for the first two years if a 10% plant coverage is attained by year one (20% by year two). This investment goes down significantly if only a couple of machine centres or units are piloted. In general, if the desire is to slow the integration of the first year (1-3 pilots only), maintenance costs and training costs may be slight and can often be covered with only slight budget overruns. Here, it should be noted that most of the authors agreed that the costs of the implementation of TPM is considered not significant compared to the costs of not implementing TPM. However, the benefit of TPM effectiveness is the OEE. One of the ways to calculate this is the impact of taking critical equipment (could be 25-30% of the process) to 85-90% of the overall OEE, which includes, the availability rate, the performance rate and the quality rate.

With this in mind, the supervisors of the company's overall maintenance program in this study believe that TPM is achievable and the possibilities needed to implement this project mostly depends on the organizational, administrative and media side requirements and this is simple when compared to the numerous benefits to be achieved through the application of the overall productivity of maintenance strategy, however, the costs of the application depends on the following:

- The existing maintenance programs used in the plants;
- The operational age of the equipment;
- The frequency of implementation and operation conditions.

As a promotion to the program, lectures should be organized, as well as conferences or training sessions to introduce the concept of TPM and its benefits to the organization. In LISCO, about 2150 employees had been trained just by year 2008. This number increased to 3932 employees at the end of 2010. This was just about the awareness sessions. Furthermore, the TPM lessons, one point lessons (OPL), the transfer of expertise between operators and maintenance personnel, were continuously made as needed during daily working hours. Table 6.2 shows the employees' number for TPM awareness sessions in 2008. Furthermore, the consultancy expenses were one of the TPM implementation costs within the company. The cost of the external consultant, who was hired to oversee the application processes, was about 2,000 Euros. The consultant visited the company eight times until the beginning of 2011, and each visit lasted from three to four days. These costs are excluding the accommodation expenses.

Calculating the speed or performance losses as well as quality losses should be best done on equipment-based method and not on plant-based method. The procedure of removing the losses, bottlenecks, and constraints are other benefit of TPM implementation. Furthermore, increasing the reliability of equipment is a savings point to show lower costs from increasing the time between failures.

As a result of the implementation of TPM in LISCO and according to the study on the framework and the steps referred to therein, it is evident that there is a marked improvement in production rate, stoppage time and the rate of defective and rejected items. The following Table 6.2 and Figure 6.2 and Figure 6.3 show the outputs of the year 2008 compared to the three proceeding years.

TABLE 6.1: TPM awareness sessions in LISCO ((LISCO, 2010)).

TABLE 6.2: Key performance indicators longitudinal rolling mill plants in LISCO (Vorne, 2008)

FIGURE 6.2: Change rate of the defective and rejected production in TS-4 & TS-5 ((LISCO, 2010)).

FIGURE 6.3: The Impact of TPM on Production Time and Stoppages, 2008 compared to 2005-2007 ((LISCO, 2010)).

Chapter 7

Conclusion and recommendation

7.1 Introduction

The study contains complete elaboration of the factors that affect the implementation of TPM. The main objective of the study was to evaluate and define the factors that are specifically faced within the manufacturing industries in Libya. The methodology adopted in this study is based upon phenomenology and research design of the case study and approach as well. An adequate amount of data from the relevant sources were collected for achieving the main objectives of the research. Secondary data were collected and has been discussed in the literature for understanding the basics of the TPM, its implementation and other associated factors. The primary data were collected through the interviews, questionnaires, document review and to identify and evaluate the factors and supporting tools that are limiting the implementation of TPM within Libyan Iron and Steel Company (LISCO).

A theoretical framework was developed while considering the findings of the relevant case study to shape the framework according to the need, which would further help the researcher in providing a dimension for achieving the objectives of the research. The research aims and objectives were also considered throughout this study. The framework developed then helped in achieving the aims and objectives of the research and helped in highlighting the factors and barriers faced during the implementation of TPM and also helped in elaborating the techniques and methods adopted for implementing TPM. The interviews developed were semi-structures to completely evaluate the barriers faced while implementing TPM in Libya. Questionnaires were also distributed among the people involved in the implementation of TPM to support and brief the findings. Further, documentation reviews were also used to check how was the application of the program and the tools and techniques used when applying TPM.

The data or information collected through the responses of the individuals through questionnaires and interviews were analysed and discussed. This analysis was done to identify the factors that are highlighted overall through the responses as the factors that have an influence over the implementation of TPM specifically within LISCO, with complete identification of the factors and the TPM activities.

7.2 Meeting the aims and objectives of the research

The overall research question was answered through achieving the aims and objectives of this study. Hence, to "investigate the factors affecting the successful implementation of TPM in LISCO", was the precise aim of this research. Ultimately, this aim has been

achieved successfully through the research objectives being fulfilled. The specific objectives of this research are defined accordingly as:

First, to achieve a theoretical understanding of total productive maintenance, other type of maintenance and TPM supporting tools, and TPM pillars, a survey of relevant literature has been stated in chapter three. This chapter also reveals, definition and philosophy of total productive maintenance, TPM elements, TPM general barriers factors, TPM benefits, TPM implementations steps. , general factors affecting successful implementation of TPM have been identified. In this study most of the common factors affecting TPM, which were previously found by many authors, have been presented in the literature review chapter and, summarising the TPM key supporting tools, and summarising of common factors affecting TPM implementation in (table 3.4). Consequently, identifying the general factors affecting successful TPM implementation has been successfully achieved.

Second, this research has adopted systems and qualitative and quantitative approaches in order to gain a wider understanding of TPM activities, TPM factors, supporting tools in the case study organisations. It also strengthens the earlier emphasis from social researchers for consistency between the purpose of research and its theoretical, methodical and methodological choices. Therefore, the objectives of this study " to assess the existing TPM activities within LISCO plants " has been successfully achieved.

Third, this research found the extent to which the Libyan manufacturing environment suited to the implementation of TPM pillars, and TPM supporting tools. Furthermore, some other unique finding regarding TPM implementation (presented in chapter 6) in the case study organisations. Consequently, examination the extent to which the Libyan manufacturing environment case study organisation suited to the implementation of TPM pillars and TPM supporting has been successfully achieved.

Fourth, the theoretical understanding obtained from the literature survey, a theoretical framework of implementing TPM successfully was developed (Figure 3.3) and has been revised in Figure 6.1. Consequently, investigating the factors of TPM implementation and TPM supporting tools, and developing a generic framework of TPM implementation within Libyan heavy industry has been successfully achieved.

7.3 Contribution to knowledge

A significant amount of research was not conducted regarding TPM in general and specifically this scarcity of research was observed for the under developed or developing countries including Libya. This study would act as an increment for the previous studies as this study contains either theoretical and empirical factors or aspects. The theoretical value of this research could be understood through following:

- The key factors of TPM activities were summarised and tabulated (Table 3.4).
- Common tools and techniques supporting the implementation of TPM system in the organisation were summarised and tabulated(Section 3.11 and Table 3.2).
- A framework of implementing Total productive maintenance introduced (see Figure 3.3). It was revised and presented in Figure 6.1.

- The significance of the TPM system and the knowledge required for understanding its advantages for the industrial sector and other companies within developing countries and Libya specifically, has been shown empirically. It can help in increasing the knowledge or information regarding TPM system and its implementation.

Basically, this research or study is the first one that has evaluated TPM system and its associated factors specifically in the context of the Libyan industrial sector. It has also highlighted the barriers that might be faced throughout the study.

This study basically helped in filling the gap of knowledge and studies for Arabian countries and specifically Libya.

Consistency and resemblance were observed within the results obtained through this study and the relevant studies conducted by other researchers. Hence this study added to the reliability of other researches.

Some of the result findings were unique considering the Libyan culture and values as they have not been studied before, hence not addressed in the literature as well.

7.4 Recommendations

- Spread the concepts and principles of Total Productive Maintenance in the company and make it the responsibility of everyone.
- Increase the skills and knowledge of the operators to carry out autonomous maintenance through their participation in training program.
- To execute intensive awareness training courses for engineers, technicians and operators to identify the concepts and principles of TPM.
- Adoption of the Information System Department based on scientific grounds in documenting the data and information for all activities of Total Productive Maintenance.
- Researcher recommends when making an assessment of TPM in the company that all managers participate.
- Mainstreaming checklist to all branches of the maintenance department, all plants, department training, research and development, quality control, department of quality, safety and environment department and all other departments in the company.
- Researcher recommends when applying the principles of Total Productive Maintenance, to work in light of the proposed improvement plan.
- Spreading a culture of continuous improvement and to encourage employees to apply.
- Encourage the small groups activities to study all the problems related with machines, equipment and environment and conditions work, and finding solutions to those problems.

7.5 Future Work

It would seem that one major trend for further study could be towards using the same framework of this study with other organisations which would extend the results and findings of this study and would also contribute towards a wider firms, thus in part resolving its problems. In this direction further research can be undertaken for example, to:

- Investigate and identify the barriers and factors affecting successful implementation of TPM in other industry. The methodology developed for the steel industry can be readily extended to other application areas within the continuous process industry. Based on the taxonomy developed, industries such as metal, pharmaceutical, textile and cement will be a good fit to adapt TPM or other lean tools that were developed for the steel industry. This could help make a comparison of real life practices between heavy and other organisations operating in Libya.
- Replicate this study with similar firms in other countries in order to conduct a comparative analysis to facilitate the development of better understanding of the issues which have been investigated. The similarities and differences of environmental and internal factors would permit further explanation of how the characteristics of organisations, across different countries work. Such an investigation, in the context of similar organisation in different countries, would assess the validity of the findings and conclusion reached by the present study.
- The present study was conceived as an initial investigation into an area of total productive maintenance in Libyan organisations, but obviously it cannot deal with all of the ramifications of the maintenance and management problems. Therefore further studies can be conducted to investigate in depth other issues, including for example, quality in maintenance and continuous improvement, management and cultural transferability, managing change in maintenance, and etc.
- Further studies can be conducted to test and evaluate the steps that were suggested by many authors to implement TPM through the proposed framework.
- Finally, as the present study has identified factors affecting successful implementation of TPM, it would be very interesting and useful to study further how these factors and obstacles can be overcome by developing a suitable framework built on the findings of this thesis. It is suggested to use the theoretical framework that was derived in this research (section 6.2, figure 6.1) which could help with such future studies.

7.6 The Research delimitations

This research will be limited to explore Total Productive Maintenance and its factors at Libyan Iron and Steel company (LISCO) in the Libyan manufacturing environment. and the delimitations are:

7.6.1 Management Level

The research was limited to TPM participant who are very close to TPM activities. They were distributed through three management levels: level one (LI) includes top management and seniors of TPM. Level two (L2), includes TPM pillars' chiefs, managers and supervisors. Level three (L3) includes the members of small activities' groups.

7.6.2 Business unit

The research was limited to two plants only, Bars and Rods Mill (TS-4) unit, and Light & Medium Sectors Mill (TS-5) unit. They were selected due to their advanced stage of the implementation process of TPM.

7.6.3 Geographical demarcation

The components of this study is limited to the Libyan manufacturing environment, thus, one of the limitations of the case study is not being able to generalize the results obtained. Therefore, the research's sample size was limited in terms of number, type, and location of participating organizations which may impact the generalizability of the findings. However, it is possible to implement the results in other Libyan organizations because of the culture similarity and work environment, as well as within the Arab countries and North Africa region.

7.6.4 The effect of Libyan crisis on LISCO

The Libyan Crisis refers to the ongoing conflict in Libya, beginning with the Arab spring protests, which led to the first Libyan civil war, foreign military intervention and the ousting and death of Muammar Gaddafi. The civil war's aftermath led to violence and instability across the country, which erupted into renewed civil war in 2014. The ongoing crisis in Libya has so far resulted in tens of thousands of casualties since the onset of violence in early 2011.

The Libyan Iron and Steel Company (LISCO) is caught up in this armed struggle that has enveloped the country as two rival governments vie for control four years after the ousting of colonel Muammar Gaddafi (Reuters, 2015).

In August 2012 Libyan Iron and Steel Company has announced that it began to restore the productive efficiency for the production of rebar after affected by the efficiency of the operation of the company during the events in Libya in 2011, where the company's production capacity of liquid steel of about 1.3 million tons and affected power supply to the company during the past period as well as the lines of communication and the restoration of part of the electric power company has been organized partly in operating iron production line moulded on the hot and the unity of the steel smelting and rolling lines (AISU, 2015).

On the other hand, the Arab iron and steel union mentioned that power outages forced LISCO, which is one of the largest steelmakers in north Africa, to cut production and close one of its factories for melting iron. Moreover, the Libyan energy sector is witnessing the worst unrest since the civil war broke out in 2011 as the impact of reduced production in the eastern gas fields needed to run power plants supplies (AISU, 2015).

The Reuters news report in May 2015 mentioned that the Libyan steel-maker (LISCO) is struggling to keep its mill rolling in a war zone. The power cuts off every night, shippers are reluctant to dock and foreign contractors are long gone. Moreover, LISCO Chairman, Mohamed Abdelmalik al-Faqih, may have an office overlooking the Mediterranean, but the steel plant in Misrata looks more like a military base where a tank guards the melt shops, mills and furnaces, and the nearby port is protected by anti-aircraft guns. Furthermore, the position of the company is not good, even worse than 2013 or 2014, but we are working, Faqih told Reuters in an interview.
Moreover, power and gas shortages are perhaps the biggest day-to-day challenge for the energy-hungry steel business as more than a dozen oilfields across Libya have been forced to shut due to protests, fighting and militant attacks (Reuters, 2015).

As a consequence of such situation, the TPM implementation program is no longer the priority of the company and is considered to be placed on hold until the country stabilizes.

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